Hydrometric Network Evaluation: An Assessment of User Needs

Northern Water Resources Studies

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Executive Summary

The Department of Indian Affairs and Northern Development (DIAND), Water Resources Division (WRD) periodically engages in review of northern hydrometric programs to determine their adequacy for present and future uses and to recommend specific network improvements to program administrators. DIAND's data needs are for water management of this resource.

This report on a user survey and the associated workshops are a part of the review process.

DIAND and the Department of the Environment (DOE) jointly manage and cost-share the operation of hydrometric networks in Yukon and the Northwest Territories (NWT). The purpose of these networks is to provide accurate, comprehensive information on the availability and distribution of water in the north, and an understanding of its physical characteristics and behaviour. At present (1990-91) there are 74 hydrometric stations in Yukon and 139 stations in the NWT. The annual cost to DIAND in 1990-91 for their share of operation and maintenance was $272K and $710K, respectively.

A growing concern of both departments is that the cost of maintaining the two hydrometric networks has remained fixed since 1985. Efforts to maximize efficiency of operations can go no further; to maintain a fixed-cost operation requires reduction in the number of network stations. Before the departments can consider network reductions, they must evaluate the adequacy of existing networks and assess the impacts of such reductions on data users. A need for more water data rather than less, has been reiterated in DIAND's recent policy statements in the Arctic Environmental Strategy (DIAND, 1990).

There are thus two fundamental directions for future network management that bear on this study: a network down-sizing to meet the exigencies of a zero-growth budget; or, alternatively, a network increase founded upon DIAND's responsibilities to the Arctic Environmental Strategy (AES). The AES emphasizes the need for a comprehensive approach to the maintenance of the arctic environment and its ecosystems. More specifically, the objective of the water program is to establish a system of water resource management that will enhance the protection of northern waters through improved knowledge and informed decision-making.

Data was obtained for this review of the hydrometric network from replies to a mailed survey of data users identified by DIAND offices in Ottawa, Yellowknife and Whitehorse; from follow-up workshops held in Yellowknife and Whitehorse; and from analysis of data request logs maintained in the NWT.

What follows represents the perceptions of the hydrometric network from a diverse array of users and water resource managers. Combined, they represent a formidable pool of knowledge about northern waters. It was difficult, therefore, to condense the wide array of opinion and comment into the limiting confines of a summary document.

The main issues which surfaced in this examination of the northern hydrometric networks in Yukon and the NWT can be organized into three strands or themes. The diverse comment under each cannot be categorized as easily. The three themes are: improvement to both data quality and response to users; rational network reduction to meet budgetary constraints; and the wise application of new resources to water management to meet the needs of the Arctic Environmental Strategy.

1. According to received comments, improvements can be accomplished by:
   - improving the quality of hard-copy reports;
   - collapsing the four main surface water reports into one; and by
   - defining what is needed, when it is needed, and where it is needed through consultation between managers and clients.

2. Network reductions can be achieved by:
   - decreasing the network to 'core' stations, funded at a level of approximately 75% of the budget, and using the remaining resources to operate a specific-need or 'dynamic' network that supplies user needs directly. This implies the identification of core stations and the development of a priority listing of dynamic sites; and/or
   - eliminating operations in high-cost regions.

3. New funding for the hydrometric network to meet the needs of the Arctic Environmental Strategy should be spent on regions or river basins facing developmental pressures. Design of network additions should derive from joint planning exercises, drawing upon both hydrometric data users and water resource managers. This design philosophy would ensure that user needs were addressed and that hydrologic regionalization was optimized.

The nature of the funding dictates that strong linkages be developed between the concept of environmental conservation and the water resources program being developed.

Maintenance of data request logs in northern offices on electronic media would facilitate future reviews. They are essential references for program performance evaluation.

The conclusions of the main report contain a number of recommendations derived from clients responses, from workshop discussions and from the analysis of data request logs. They are as follows:

1. IWD should correct the poor quality of recent data publications.

2. The northern offices of IWD and WRD should acquire the necessary computer hardware and software to supply clients with hydrologic data in a variety of formats, e.g., CD-ROM, popular PC spreadsheets, ASCII.

3. IWD and DIAND should institute an ongoing advertising campaign to create client awareness of ancillary hydrologic data available in IWD and WRD offices.

4. Water resource managers and data clients should jointly define the term: environmental water resource network.

5. Water Survey of Canada should institute a new labelling convention to describe streamflow through coarse bed materials when no surface flow is evident, for example,'Flow present but unmeasurable'.

6. New techniques should be developed or adopted by WSC to obtain water level and flow data during the spring breakup.

7. The public of the northern territories would be well-served if privately-collected, third-party hydrologic information were to be assembled in an easily accessible database.

8. This program will require the identification of long-term or 'master' stations which would be retained indefinitely. Their maintenance should be

of higher priority than short-term surrounding stations established for research or development purposes. The short-term, dynamic network should be slaved to the master stations in uniform hydrologic regions.

9. Strategic network planning of this nature should utilize input from the user community. Ideally, there should be joint planning sessions.

10. DIAND should seek to establish appropriate regulations and financial structure to receive and manage third-party contributions for jointly-funded northern water management ventures.

11. Improve the data collection programs at existing stations to provide better information at spring breakup in the midst of the annual ice run.

12. Improve the mid-winter low-flow measurement program, especially for smaller Yukon rivers identified by DFO as salmon rivers.

13. Intensify the data collection program in open water periods for those stations with unstable river beds, i.e., gravel or sand-bed rivers.

14. Replace electro-mechanical field instruments with solid-state systems less likely to fail in climatic extremes.

15. Dedicate some new resources to initiate short-term, special water management needs stations, i.e., the hydro-electric development needs of Yukon Electric. Period of operation should be identified at the outset. This is a dynamic aspect of networking which could be invaluable in the scientific sense as well as in the management sense, by seeking correlations of the short-term data with that from the long-term baseline network.

16. Expand into new areas of resource development or hydrologic significance such as the Arctic Islands.

17. Data request logs should be maintained on an electronic database in the northern offices of IWD or DIAND WRD.

Sommaire

La Division des ressources hydrauliques (DRH) du ministère des Affaires indiennes et du Nord canadien (MAINC) effectue périodiquement des études sur les programmes hydrométriques du Nord afin de déterminer le bien-fondé de leur utilisation actuelle et future et de recommander aux administrateurs de programmes des améliorations particulières aux réseaux. Les besoins du MAINC en matière de données se rapportent à la gestion des eaux.

Le présent rapport découlant d'un sondage auprès des utilisateurs et des ateliers connexes fait partie du processus d'étude.

Le MAINC et le ministère de l'Environnement (ME) se partagent la gestion et les coûts de fonctionnement des réseaux hydrométriques du Yukon et des Territoires du Nord-Ouest (TNO). Ces réseaux permettent d'offrir des données précises et détaillées sur la disponibilité et sur la distribution des eaux dans le Nord, en plus de mieux comprendre leurs caractéristiques et les déplacements y afférents. à l'heure actuelle (1990-1991), on compte 74 stations hydrométriques au Yukon et 139 dans les TNO. En 1990-1991, les frais annuels du MAINC au chapitre du fonctionnement et de l'entretien se sont élevés à 272 000 et 710 000 $ respectivement.

Les deux ministères se préoccupent du fait que le coût d'entretien des deux réseaux hydrométriques soit demeuré fixe depuis 1985. Il est impossible de tirer davantage profit des opérations; pour maintenir un coût fixe, il faut réduire le nombre de stations. Avant que les ministères puissent penser à réduire le réseau, ils doivent évaluer le bien-fondé des réseaux existants et les répercussions de ces réductions sur les utilisateurs de données. La nécessité de disposer d'un nombre plus grand de données sur l'eau plutôt que moindre a été soulignée à maintes reprises dans les récents énoncés de politique du MAINC contenus dans la Stratégie pour l'environnement arctique (MAINC, 1990).

Il découle donc de cette étude deux orientations fondamentales à l'égard de la future gestion des réseaux: la réduction du nombre de stations afin de satisfaire aux exigences d'une croissance nulle ou encore l'augmentation du réseau fondée sur les responsabilités du MAINC relativement à la Stratégie pour l'environnement arctique (SEA). La SEA souligne la nécessité d'adopter une approche globale en vue de protéger l'environnement arctique et ses écosystèmes. Plus précisément, le programme a pour but d'établir un système de gestion des ressources en eau qui facilitera la protection des eaux du Nord grâce au perfectionnement des connaissances et à la prise de décisions éclairées.

Les données applicables à l'examen des réseaux hydrométriques proviennent des réponses à un sondage effectué auprès des utilisateurs par les bureaux du MAINC situés à Ottawa, à Yellowknife et à Whitehorse, des ateliers de suivi présentés à Yellowknife et à Whitehorse et de l'analyse du journal des demandes de renseignements tenu dans les TNO.

L'exposé suivant tient compte de l'opinion de différents utilisateurs et de divers gestionnaires de ressources en eau au sujet des réseaux hydrométriques. Tous ensemble, ils représentent un puits de connaissances sur les eaux du Nord. Il est toutefois difficile de résumer tous les commentaires en un document sommaire.

Les principales questions qui ressortent de cet examen des réseaux hydrométriques du Yukon et des TNO peuvent être réparties en trois thèmes. Les différents commentaires relevant de chacun ne peuvent être catégorisés aussi facilement. Les trois thèmes sont l'amélioration de la qualité des données et des réponses aux utilisateurs; la réduction rationnelle des réseaux pour satisfaire aux contraintes financières et l'application judicieuse de nouvelles ressources à la gestion des eaux afin de satisfaire aux besoins énoncés dans la Stratégie pour l'environnement arctique.

1. Selon les commentaires reçus, les améliorations suivantes doivent être apportées:
   - améliorer les rapports imprimés;
   - concentrer les quatre principaux rapports sur les eaux de surface en un;
   - définir les besoins, le moment où les données doivent être disponibles et le lieux au moyen de la consultation entre gestionnaires et clients.

2. Pour réduire les réseaux, il faut:
   - diminuer le réseau de façon à retenir les stations de base seulement et les financer selon un niveau d'environ 75 p. 100 du budget et utiliser les ressources qui restent pour exploiter un réseau dynamique axé sur des besoins particuliers exprimés directement par les utilisateurs. Il faut donc déterminer les stations de base et dresser la liste des lieux prioritaires;
   - éliminer les activités dans les régions où les coéts sont élevés.

3. De nouvelles mises de fonds applicables aux réseaux hydrométriques visés dans la Stratégie pour l'environnement arctique devraient être consacrées aux régions ou aux bassins fluviaux oé s'exercent des pressions. La conception des

ajouts aux réseaux devrait découler d'exercices de planification mixtes faisant appel aux utilisateurs de données hydrométriques et aux gestionnaires des ressources en eau. Grâce à ce principe de conception, les besoins des utilisateurs seront pris en considération et la régionalisation hydrologique optimisée.

- Étant donné la nature du financement, il faut établir des liens solides entre le concept de la conservation environnementale et le programme de gestion des ressources en eau.

La tenue d'un journal des demandes de données sur média électronique dans les bureaux du Nord faciliterait les examens à venir. Il s'agirait d'un systéme de référence essentiel à l'évaluation du rendement du programme.

Les conclusions du rapport principal contiennent un certain nombre de recommandations faisant suite aux réponses des clients, aux discussions en atelier et à l'analyse du journal de demandes de données, notamment:

1. La DEI devrait améliorer la qualité des publications de données récentes.

2. Les bureaux de la DEI et de la DRH devraient faire l'acquisition du matériel et du logiciel nécessaires pour fournir à leurs clients des données hydrologiques sous différentes formes, par exemple disque compacte à mémoire morte, tableurs, code standard américain pour l'échange d'information.

3. La DEI et le MAINC devraient lancer une campagne d'information pour mettre les clients au courant de la possibilité de se procurer des données hydrologiques accessoires auprès des bureaux de la DEI et de la DRH.

4. Les gestionnaires de ressources en eau et les clients devraient définir ensemble l'expression réseau environnemental des ressources en eau.

5. La Division des relevés hydrologiques du Canada devrait instaurer une nouvelle convention visant à décrire le débit d'eau traversant les matériaux

rugueux du lit lorsque l'écoulement en surface n'est pas évident, par exemple, écoulement d'un cours d'eau présent, mais non mesurable.

6. De nouvelles techniques devraient être mises au point ou adoptées par la Division des relevés hydrologiques afin de permettre la cueillette des données sur le niveau d'eau et le débit pendant la débâcle du printemps.

7. Le public des Territoires du Nord-Ouest serait bien servi si les renseignements recueillis par les tierces parties du secteur privé étaient rassemblés dans une base de données facilement accessible.

8. Ce programme donnera lieu à la désignation des stations à long terme ou stations maîtresses permanentes. Leur maintien devrait occuper un rang plus élevé que celui des stations périphériques à court terme établies à des fins de recherche et de développement. Le réseau dynamique à court terme devrait être relié aux stations maîtresses dans les régions hydrologiques uniformes.

9. La planification stratégique d'un réseau de cette nature devrait reposer sur la collectivité utilisatrice. Idéalement, il faudrait organiser des séances de planification mixtes.

10. Le MAINC devrait chercher à établir un règlement approprié et une structure financière destinés à gérer les contributions des tierces parties dans le cas de projets de gestion des eaux du Nord financés conjointement.

11. Il faudrait améliorer les programmes de collecte de données dans les stations afin de fournir une meilleure information pendant la débâcle du printemps au milieu de la descente annuelle des glaces.

12. Il faut améliorer le programme de mesure du débit minimal du milieu de l'hiver, particulièrement dans les plus petits cours d'eau du Yukon désignés par le MPO comme rivières à saumon.

13. Il faut intensifier le programme de collecte des données dans les périodes de haut débit dans le cas des stations où le lit des cours d'eau est fluctuant, par exemple, lit de sable ou de gravier.

14. Il faut remplacer les instruments d'observation électromécaniques par des appareils à transistors moins sensibles aux rigueurs du climat.

15. Il faut consacrer de nouvelles ressources à l'établissement de stations spéciales de gestion à court terme des eaux, notamment dans le cas des projets hydroélectriques de la Société Yukon Electrical Limited. Les périodes de fonctionnement doivent être définies dès le début. Voilè un aspect dynamique du réseau qui pourrait être inestimable, sur le plan scientifique aussi bien que du point de vue administratif, par l'établissement de corrélations entre les renseignements à court terme et les données de référence à long terme.

16. Il faut élargir le réseau de façon à englober les nouveaux secteurs de développement des ressources ou les projets hydrologiques d'envergure comme l'archipel Arctique.

17. Le journal des demandes de données doit être incorporé à une base de données électronique dans les bureaux du Nord de la DEI ou de la DRH du MAINC.

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Funds for this study were provided by DIAND, Water Resource Division, Northern Water Resources Studies Program in Ottawa. The authors wish to acknowledge all the assistance, freely given, by northern managers of Water Resources Division, Northern Affairs Program of DIAND. Special thanks are due Brian Latham, Regional Hydrologist in Yellowknife and Ric Janowicz, Acting Regional Manager in Whitehorse for their timely supply of client addresses to use in the mailed survey. Digging out addresses is an odious task - many thanks to you and your staff. Our thanks also to the many respondents, in government and industry, who took the trouble to provide a wealth of thought-provoking information about their perceptions of the northern fresh water resource. Our thanks also to the peer reviewers and for their many constructive comments and suggestions. Finally, a special note of appreciation to David Milburn, DIAND scientific authority for this study; he has been most supportive. All errors of interpretation in this document are solely the responsibility of Northwind Consultants .

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1.0 Introduction:

Yukon and the Northwest Territories (NWT) together measure just less than four million square kilometres in area and between them they possess approximately 30% of Canada's freshwater resources. This vast, extremely valuable resource is monitored at only 181 stations for streamflow (Prowse, 1990) and at 34 additional stations for water level. The exceedingly sparse hydrometric data network is a direct reflection of the northern territories small population rather than their huge size or the importance of the water resource. Indeed, the uneven distribution of these few hydrometric stations within the territories reflects the differences in regional population densities. Thus, most of the stations in Yukon are located in the south, in the Yukon River Basin; and most of the NWT stations are located in the more densely populated Mackenzie River valley and the adjacent central Arctic mining region. Because the networks are so sparse and because the data collection travel costs are so high, the data which are collected are highly valued. Department of Indian and Northern Affairs (DIAND), which is legally charged with territorial water resource management, has great incentives therefore, for the maintenance of an effective, efficient hydrometric network in the northern territories, one which satisfies user needs.

1.1 Intent of User Survey:

For these reasons, DIAND Water Resources Division (WRD) periodically engages in reviews of northern hydrometric programs to determine their adequacy for present and future uses and to recommend specific network improvements to program administrators. This report on a user survey and associated workshops is a part of that process.

DIAND's data needs relate to a number of northern water management priorities, such as those recently defined in an evaluation study of 74 NWT water management stations (Wedel, 1991). The rank-ordered priorities are:

- instream use;
- community needs for water supply and sewage disposal;
- interjurisdictional;
- recreation;
- industrial development;
- highways; and
- river basin planning.

Priorities for Yukon water resources management, although not yet formalized, are expected to be similar in concept, differing only in rank order.

DIAND and the Department of the Environment (DOE) jointly manage and cost-share the operation of hydrometric networks in the territories. The purpose of these networks is to provide accurate, comprehensive information on the availability and distribution of water in the north, and an understanding of its physical characteristics and behaviour. At present (1990-91) there are 74 hydrometric stations in Yukon and 139 stations in the NWT. The annual cost to DIAND in 1990-91 for their share of operation and maintenance was $272K and $710K, respectively. Total annual cost for the joint operation is in excess of $ 2.2 million dollars.

A growing concern of the departments is that the cost of maintaining the two territorial networks has remained fixed since 1985. Efforts to maximize efficiency of operations can go no further; to maintain a fixed-cost operation requires reduction in the number of network stations. Before the departments can consider network reductions, they must evaluate the adequacy of existing networks and assess the impacts of such reductions on data users. Other studies have addressed this growing problem, both at the national scale (Water Resources Branch, 1989) and at the regional level (Davar and Brimley, 1989; Wedel, 1986). Moreover, Pearse et al (1985) in the final report on the Inquiry on Federal Water Policy and in the policy itself, are specific on the need to extend water data programs in the north. The need for more water data rather than less, has been reiterated in DIAND's recent policy statements in the Arctic Environmental Strategy (DIAND, 1991).

There are thus two fundamental directions for future network management that bear on this study: a network down-sizing to meet the exigencies of a zero-growth budget; or, alternatively, a network increase founded upon DIAND - WRD responsibilities to the Arctic Environmental Strategy (AES). The AES emphasizes the need for a comprehensive approach to the maintenance of the arctic environment and its ecosystems. More specifically, the objective of the water program is to establish a system of water resource management that will enhance the protection of northern waters and its associated ecosystems through improved knowledge and informed decision-making.

1.2 Survey Strategies:

Information for this study was obtained in several related ways: by analysis of responses to a mailed survey questionnaire; by face-to-face interactions between users of the data and water resource program managers at one-day workshops in Yellowknife and in Whitehorse; and by analysis of NWT data request logs kept by Water Survey of Canada (WSC), Yellowknife. Classification of users by groups, the regionality of requests, and the nature of data requested were obtained from the request logs.

1.3 Other Report Sections:

Survey returns are summarized in Section 4, the workshop proceedings in Section 5, and the analysis of the Yellowknife user request logs in Section 6. Section 7 discusses the obtained information in the context of several possible long-term directions for the management of northern water resources. When feasible, program directions supplied by clients are presented as recommendations in Section 7. Section 8 is a listing of reference material.

Appendices A through E contain a copy of the mailed questionnaire, the survey mailing list, detailed analysis of the survey returns and workshop proceedings.

2.0 Relationships to Other Studies:

A number of Yukon- or NWT-specific water resource studies provide background information about the northern hydrometric networks' growth and the uses to which the data are put. Yukon network history is described by Kreuder (1980). Janowicz (1984) identifies hydrologic deficiencies and redundancies in an assessment of the hydrometric network stations in the Yukon River Basin in the context of a comprehensive river basin management plan. A further study by Janowicz (1986) defines four hydrologic regions in Yukon by the use of discriminant and factor analyses to define the clustering tendencies for floods and for low flows. The assessment of active hydrometric stations is extended to the whole territory in a station-by-station analysis (McFarland, et al; 1988), following procedures originally described by Wahl and Crippen (1984). The purpose of regional stations, as described by Kreuder and Leith (1988), is to provide a spatial understanding of the water resource and thus to allow streamflow estimates to be made for ungauged river basins. Spatial information gleaned from the Yukon network is described mathematically through pairwise correlation analysis of peak and low flows by Klohn Leonoff Yukon (1988).

In the NWT, recent work by Wedel (1990) addressed the inadequacy of the territorial regional network and performed a station-by-station evaluation of the project-specific hydrometric stations (1991). Conly (in progress) is completing single station evaluations for the remaining stations in the NWT network; those funded by IWD of Environment Canada.

Five earlier, Canadian hydrometric user surveys are discussed briefly in the following sections in order to provide a context for the results from this survey.

2.1 NWT User Survey, 1985:

The NWT user survey in 1985 was conducted as part of an Inland Waters Directorate (IWD) review of the total hydrometric network in Department of Environment's Western and Northern Region, i.e., Manitoba, Saskatchewan, Alberta and the NWT. The study addressed the ability of the existing network to describe regional hydrologic characteristics, an item of national interest, since regional hydrology can be used to provide inventories of fresh water in a region. As the NWT report (Wedel, 1986) made clear, the stations operated for management purposes were considered to be fixed, i.e., located to meet specific needs, and therefore not amenable to relocation in order to improve their hydrologic data. Many of these stations were, however, located on undeveloped streams and were therefore suitable for inclusion in regional

studies. One of the report's principal conclusions was that NWT hydrology could not be adequately characterized by the six regions outlined in the Northern Inland Waters Act (1972) and used in the 1983 Five-Year Hydrometric Expansion Proposal (DIAND & DOE, 1983). Sixty regions were suggested, based on physiography, vegetation and permafrost distribution.

User responses to the 1985 survey identified a number of information needs for the NWT. Needed were:

- much-improved, interpretive reporting of regional water resources;
- increased research on ice jams, sediment transport, and floods;
- studies of southern development impacts on northern rivers;
- higher station densities to facilitate hydrologic extrapolation, an extra 30-45 stations;
- hydrologic and sediment data for the Arctic Islands;
- improved hydrometric data accuracy in freezeup and breakup;
- better water quality data and more of it;
- improved water level forecasting in the Mackenzie system;
- improved hydrologic characterization for highway engineering design;
- small-stream hydrology in transportation corridors; and
- flexibility in network design to address emerging management needs.

The data needs by type were:

- daily discharges;
- monthly mean flow;
- flood flow;
- low flow;
- sediment: suspended, bed material; and
- water level data from river stations.

2.2 Manitoba User Survey, 1985:

The Manitoba-Northwestern Ontario user survey (McLaurin et al, 1986) was conducted in parallel to the 1985 study in NWT and addressed the same network management issues. The responses identified 14 hydrometric data uses. In order of the frequency mentioned, they were:

- aquatic habitat studies;
- flow forecasting;

- small basin hydrology with transfer value;
- river channel engineering works;
- transboundary water management;
- recreation and other instream uses;
- irrigation;
- floodplain construction;
- river diversion;
- water apportionment;
- long-term hydrologic trends;
- agriculture;
- domestic, industrial water supply; and
- forestry.

Also identified were site-specific or regional needs, data types required, network adequacy, sediment data needs, and user needs for real-time data.

2.3 Ontario User Survey, 1986-87

As with the surveys in Western and Northern Region of IWD, this data user survey was regional in scope and part of a Canada-wide review by DOE of federal involvement in water resources management. It was designed to provide a client perspective on water resource data collection programs for the Ontario Region.

The survey (Goertz, 1987) of 367 users indicated that hydrometric network densities were insufficient, especially in northern Ontario, and that information deficiencies existed for small catchments and urban watersheds. The provision of hydrologic analyses to users was suggested, as were changes to the configuration of the hydrometric network. There was a strong interest in electronic data acquisition. Respondents were asked to classify their data needs according to type, accuracy requirements and location. Information was also solicited for specific hydrometric data uses.

2.4 IWD Western and Northern Region Network Study Report Summary, Calgary, 1986:

The report (Water Resources Branch, Calgary, 1986) summarizes the results of four individual hydrometric program reviews done in 1985 in Alberta, Saskatchewan, Manitoba and the Northwest Territories.

Its purpose was to evaluate the federal commitment to hydrometric data acquisition from the regional perspective, in contrast to the more restricted viewpoint of provincial/territorial assessments usually done. The larger, regional review led to improved understanding of the linkages between the federal hydrologic data acquisition programs in Manitoba, Saskatchewan, Alberta and the Northwest Territories. The data needs identified in the Alberta portion were:

- hydrologic process studies;
- water quality;
- recreation;
- consumptive use;
- aquatic habitat management;
- forest management;
- interjurisdictional water management;
- irrigation;
- regional hydrology;
- urban runoff;
- water apportionment;
- national water inventory; and
- fisheries research.

Other key findings obtained from the roll-up of the four provincial/territorial reports were that:

- some of the polled federal agencies were not aware of their own day-to-day water data requirements nor were they aware of the data source or its diversity;
- remote areas of the Western and Northern Region had insufficient data to describe their regional hydrology;
- the federal interest in regional hydrology was nowhere defined; and that

- there was no mechanism in place for IWD to evaluate the performance of the existing federal management network against its own or other federal agency objectives.

The report concluded with a number of recommendations to address these negative findings. Many of these have since been acted upon.

2.5 Davar and Brimley, 1989:

The user survey conducted by Davar and Brimley was part of a larger study (Environment Canada and New Brunswick Municipal and Environmental Affairs, 1988) to analyze the effectiveness of the hydrometric network in New Brunswick. The New Brunswick user survey was sent to 505 potential clients; 251 responses were received. The survey identified the users, the data types required and their frequency of use. Some findings of the survey were that:

- 80% of the respondents required hydrologic data, of whom 85% required interpreted data;
- over 50% of the respondents to the question on data transfer indicated a desire for an accuracy of ± 10%;
- 50% felt that the station density was inadequate; and that
- a high percentage of users made use of the data on at least a monthly basis.

2.6 DOE, 1989

In 1989, the Water Advisory Committee (WAC) of the Canadian Council of Resource and Environment Ministers (CCREM) asked for a report on the adequacy of the Canadian hydrometric and water quality networks in Canada. Because of the large membership in WAC and its geographic dispersion, its members were polled by mailed survey. The findings were summarized by Water Resources Branch (1989), Inland Waters Directorate of Environment Canada. The conclusions drawn from the survey read as follows:

1. The Surface Water Quantity Agreements are appropriate instruments under which the two levels of government should continue to collect surface water and sediment data in the foreseeable future.
2. The Water Quality Agreements represent the best mechanism for collecting national water quality data.
3. Drinking water quality is the major public concern today.

4. The current water quantity networks are not adequate to meet present or future needs, especially in northern Canada.
    - Mackenzie Basin Study identified the need for 75 new hydrometric, and 100 other water quality, sediment, meteorological and snow course stations.
    - At least 150 new stations on small watersheds are needed in Canada.
    - At least 200 specific project stations are needed to manage major development in Canada.
    - There is a need to link water quality, meteorology, and streamflow networks.
    - Sediment transport characteristics are of growing importance because of the ability of sediment to transport pollutants.
5. New, modern equipment is needed to operate the hydrometric program.
6. The water quality programs of the federal, provincial and territorial governments need to develop common methodologies, quality assurance programs, and program management perspectives.
7. There is a growing need, nationally, for water resource data interpretation.
8. The groundwater aspect of the hydrologic cycle needs to be incorporated into systematic water resource data collection programs.
9. Biological monitoring, a very costly element in water quality programs, might be incorporated in a cost-effective manner, if its needs could be addressed in combination with physio-chemical monitoring programs.

Probably their most important conclusion was that "...the investment in long-term, comprehensive streamflow, water level, and sediment data, which takes many years to collect and interpret, is the best way to ensure wise decisions are made in the future about Canada's water."

2.7 Multi-Use Networks:

Historic surveys and other hydrometric studies suggest that most specific-purpose stations generate data useful for other, secondary purposes. Secondary usage is impossible to evaluate, since IWD hydrologic data are all in the public domain and widely accessible. Evaluation of primary hydrologic data uses alone are sufficiently complex because of the variable needs of the funding agencies in DOE and DIAND. For example, Conly (1991, pers.

comm.), in an on-going evaluation of federal aspects of the NWT network, distinguishes four water management needs of funding government departments, i.e., DIAND and DOE. Many hydrometric stations in the NWT network satisfy more than one resource management need as illustrated schematically in Figure 1.

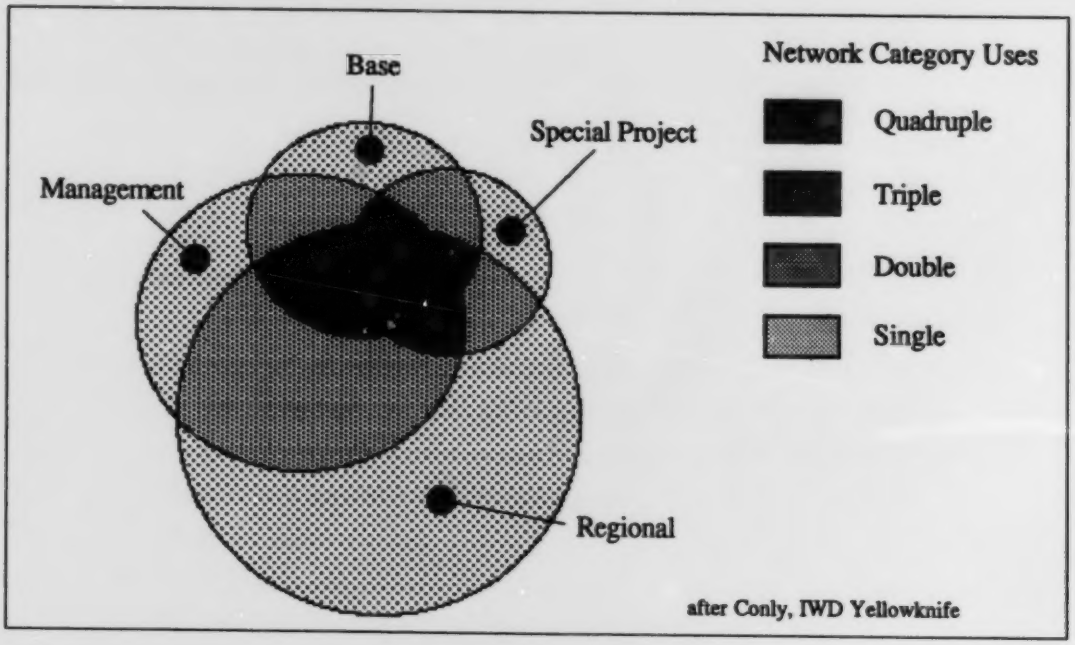

Figure 1: A schematic representation of four network elements in the NWT hydrometric network and their overlapping characteristics

The four, overlapping network elements are described as follows:

1.Base Network: consists of basin inventory stations used to determine the water resource potential of a given basin (or region) for a national inventory of NWT water resources.

2. Management or Development Network:- consists of stations needed to manage and develop the water resources on a territorial or national scale. Some of these are a subset of the base network.

3. Regional Network:- determines regional hydrology and defines hydrologically similar regions in the NWT; also defines hydrologic responses and flow patterns within individual basins; many stations are subsets of the previous two classes.

4. Special Project Networks:- usually of short duration for special projects or very specific purposes; may or may not be subsets to first three classes.

3.0 Methods:

Information used in this report was acquired by three distinct methods:

Method 1 was a conventional user survey using mailed questionnaires.

Method 2 consisted of follow-up, regional workshops in Yellowknife and Whitehorse.

Method 3 assembled information from analysis of data request logs maintained by the Water Survey of Canada in Yellowknife.

Together, sufficient information was gathered to perform meaningful analysis.

3.1. Mail Survey:

3.1.1 Questionnaire Development:

A questionnaire was developed that requested users

- to discuss hydrometric data formats as provided by IWD;
- to discuss network suitability in terms of specific sites and/or in a regional context as it applied to their specific needs;
- to define needs not met;
- to define impacts of network reduction;
- to comment on costs;
- to provide opinion on the feasibility of asking water licensees to bear the data collection costs for stations affected by their development; and
- to provide opinion on the concept of integrated networks in an environmental context.

The questionnaire, found in Appendix A, was mailed to 211 known or prospective hydrometric data users.

3.1.2 Acquisition of User Lists:

Staff of Water Resources Division, DIAND, in Ottawa, Yellowknife and Whitehorse, and of IWD in Vancouver and Yellowknife supplied individual or agency contacts for inclusion in the questionnaire mailing. Compilation of the mailing list, shown in Appendix B, required that 'hydrometric data user' be defined. For purposes of this study and report, hydrometric data users were defined as all those who use Water Survey of Canada data to perform

hydrologic analysis and research, to facilitate or to regulate anthropological activity, or to plan and construct engineering works associated with surface water resources.

3.2. Workshops:

Returns from the mailed survey were used to develop an agenda for the two northern workshops, held on March 5, 1991 in Yellowknife and on March 7, 1991 in Whitehorse. Invited participants, representing the spectrum of hydrometric data users, were identified by the contractor in consultation with DIAND water resource management staff. Letters of invitation were sent out to participants via FAX because of time constraints.

Handouts were prepared to give participants an overview of the user survey progress. The material included survey response summaries and several classifications; by user agency, region, and by data needs.

The agenda suggested for the workshops was as follows:

Morning Session, (0830-1200):

- Presentation of preliminary results from user survey
- Perspectives on NWT/Yukon hydrometric data programs
  - -program managers
  - -research and academic community
  - -industry
  - -consultants

Afternoon session, (1300-1700)

- Development of one or more hydrometric management matrices.
- Future directions

3.3 Data Request Logs - Yellowknife:

WSC Yellowknife data request logs provided a valuable, additional source of information which supplemented the survey conducted. The logs would have lent themselves more easily to analysis had they been kept on electronic media rather than in hard copy only. The record was, nevertheless, of great value. Unfortunately, no similar data base was available for Yukon.

Three years of data requests, 1988-90, were obtained from the data control section of IWD, Yellowknife for analysis in this study. The requests were analyzed to identify user categories, stations or regions of data request, and the data type requested.

4.0 Results:

4.1 Mail Survey Responses:

Sixty-four responses were received from a mailing of 211 questionnaires. The address listing is attached as Appendix B. In part, the relatively low response rate of 30% could be attributed to the nature of the questionnaire, which required written, reasoned responses and could therefore not be completed quickly. In addition, the questionnaire assumed the respondent's familiarity with the northern hydrometric networks, data types, operating conditions and difficulties with northern logistics. The positive aspect is that the replies were from people who had real concerns with the hydrometric networks of northern Canada. A number of replies included the comment, "Oh no, not another survey," so the current widespread use of user surveys is also a perceived reason for the low rate of return. Even so, the 64 responses were detailed and they provided a comprehensive user perspective of hydrometric data use. The number of returns was sufficient to allow some conclusions to be made on client opinions of northern hydrometric networks. Further detailed analyses, beyond the summaries by topics in the following sections, is found in Appendix C. Figure 2 illustrates the client groupings in the 211 mailings.

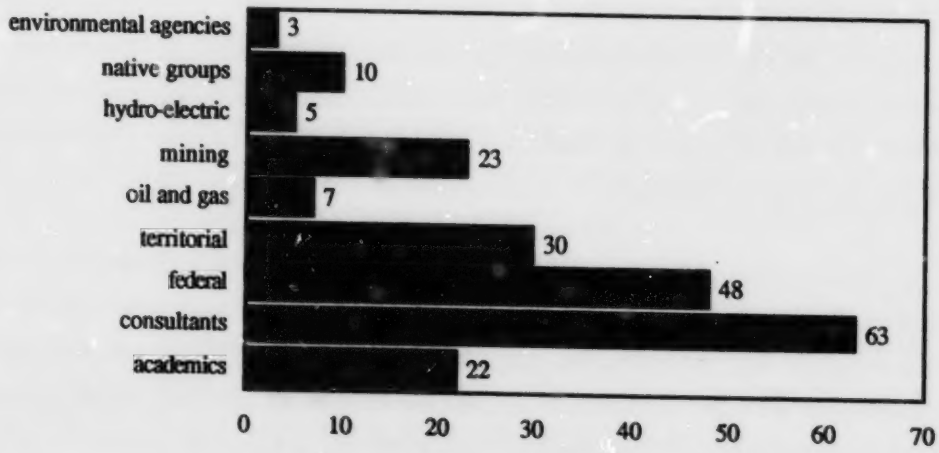

Figure 2: Client groupings in survey mailing; n = 211

Survey responses were received from federal and territorial government agencies; the petroleum, mining, transportation and hydro-electric industries; from consultants and the research community. For the sake of homoscedasticity, ie., uniform sample size, the

petroleum, mining, transportation and hydro-electric industries were lumped as 'industry' in this analysis. Figure 3 shows the responses received broken down by client group.

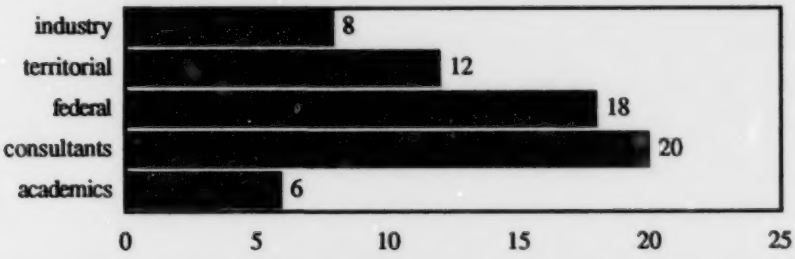

Figure 3: Number of user survey responses by client groupings; n=64

Figure 4 provides a comparison by client grouping of the survey responses to the original mailings. To enable easy comparison the data are presented as percentages of the respective totals.; For the initial mailing, n = 211; and for the responses, n = 64. There is reasonable correspondence evident for all client groups except for the native and environmental groups where there were no returns, and for the mining industry, where only a small number replied.

Although it has been said that the questionnaire had not been designed for short, yes-no answers, there were a number of queries in questions 1, 2, 3, 4, 5, 7, 8 and 9 which could be answered yes-no. The yes-no reponses were summarized on a master response spreadsheet and are illustrated in Figure 5.

Examination of the data in Figure 5 show that 35 or more of the 64 respondents felt that creation of an environmental network was desirable, that water licence holders should pay for water resource data programs, that more, not fewer hydrometric stations were needed in the northern territories, that electronic media was a desirable means of data dissemination, and that they received hydrometric data books. The two lowest positive responses were for use of CD-ROM data formats and real-time data.

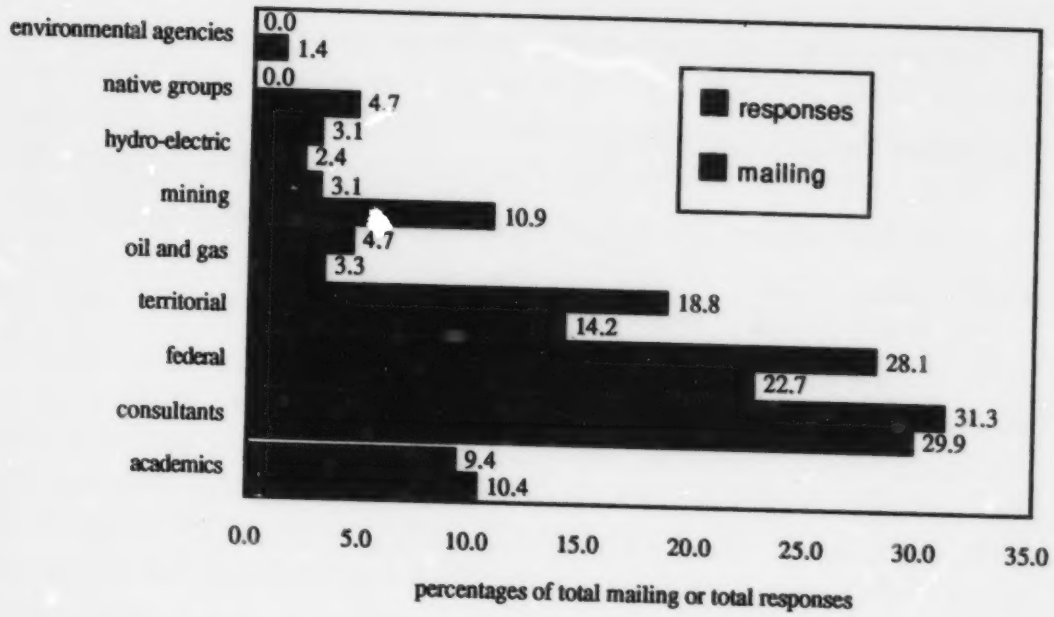

Figure 4: Comparison of client mailing to client response fractions

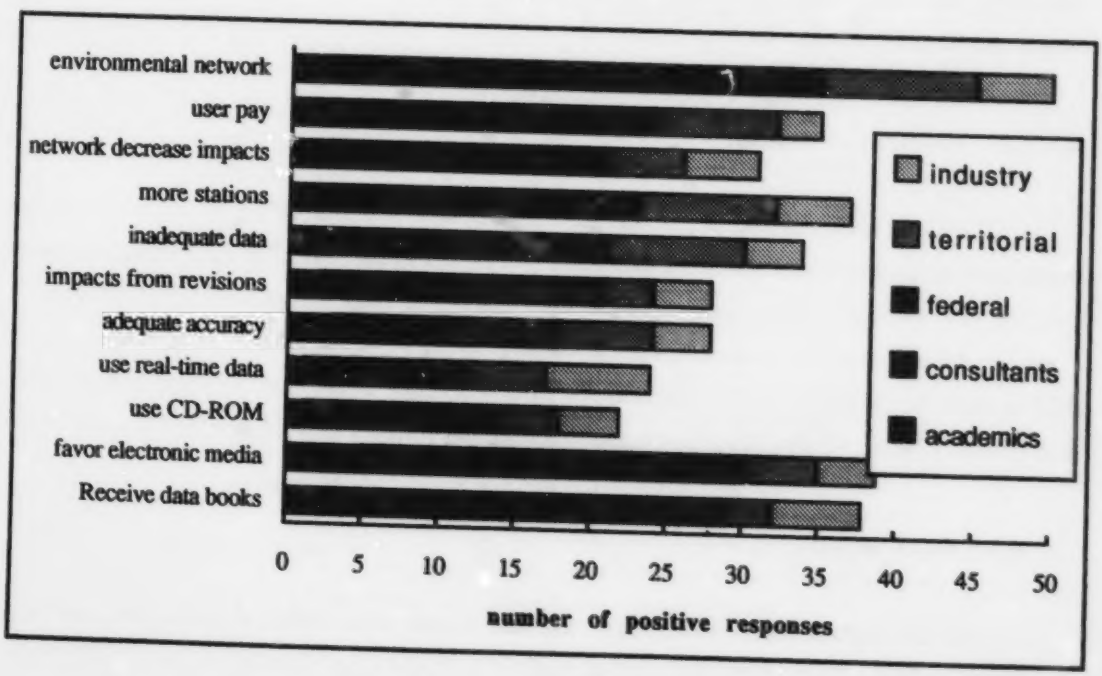

Figure 5: Analysis of questionnaire responses by client groups; n=64

Reply commentary is summarized in the following sections.

4.1.1 Data Formats and Accuracy:

The first five questions of the questionnaire, Appendix A, related to this topic.

4.1.1.1 Data books:

Thirty-eight, or 59 % of the respondents received the data books. They were considered to be useful as a general reference tool for a wide variety of applications, from engineering design to their use as teaching aids in universities. In some cases, the data books were consulted on a daily basis. A common complaint from several respondents was that the quality of printing and binding of the data books had recently declined. Specifically identified was the character format which was difficult to read, especially for numbers '6' and '8'. A more legible typeset was suggested. There were other suggestions for improving data dissemination to clients via hard-copy, such as the integration of the four main water data reports into a single document; provision of easier access to water level data for rivers, especially for the breakup; provision of rating curve equations in the publications; and more timely publication.

4.1.1.2 Electronic media:

Data made available on electronic media was acceptable to 39 or 61% of the respondents. Reservations about its exclusive use centered on concerns for infrequent users and for new clients. Other concerns were with electronic data formats of supplied data. A common request was for data compatibility with popular PC spreadsheet formats, e.g., Lotus 123 or ASCII. Eleven of the 64 respondents now owned or were about to acquire CD-ROM equipment. A gradual transition from paper to computer formats was suggested.

4.1.1.3 Data accuracy:

Twenty-eight replies, 44%, suggested that clients were satisfied with published data accuracy; only six users were dissatisfied, mainly with the flow data in breakup, mid-winter and the freezeup. One common remark was that there were no independent data against which

to assess WSC records. Equally prevalent was the feeling that clients were in no position to evaluate data accuracy and that they relied on WSC to generate high-quality data. The dissemination of data review results to the users was a major concern as was the continued validity of flow models which had been calibrated with unrevised information, especially for the routing models on the Slave and Mackenzie rivers. A like number of respondents, 28, felt that data revisions would affect their work.

4.1.2 Client Data Needs and Network Inadequacies in a Spatial Sense:

Clients identified regional or specific station data use in response to question 6 (a). The returns were used to develop the matrix shown in Table 1, a breakdown of regional data use versus nine client categories. The results show that the Mackenzie Region hydrometric data were used most frequently by clients. Figure 6 summarizes the same information graphically, but reorganized by frequency of regional data use.

	federal	territorial	municipal	petroleum	mining	transport	hydro	consultants	researchers	
Great Slave Basin	4	9		3		2	1	4	1	24
Great Bear Basin	1						1	3	1	6
Mackenzie River Basin	7	8		7	1	4	1	11	6	45
Arctic Islands	1							1	2	4
Baffin	1							1		2
Hudson Bay, Foxe Basin	3	1			2			4	1	11
Arctic Coast					2	1		2		5
Yukon Interior	6	3	1			1	1	2	7	21
Western Yukon Mountains	1	1						4	2	8
Northern Yukon Interior	4	1				1	1	1	2	10
Yukon North Slope	1							1	1	3
Column Totals	29	23	1	10	5	9	5	34	23	

Table 1: Client groups' regional data requirements

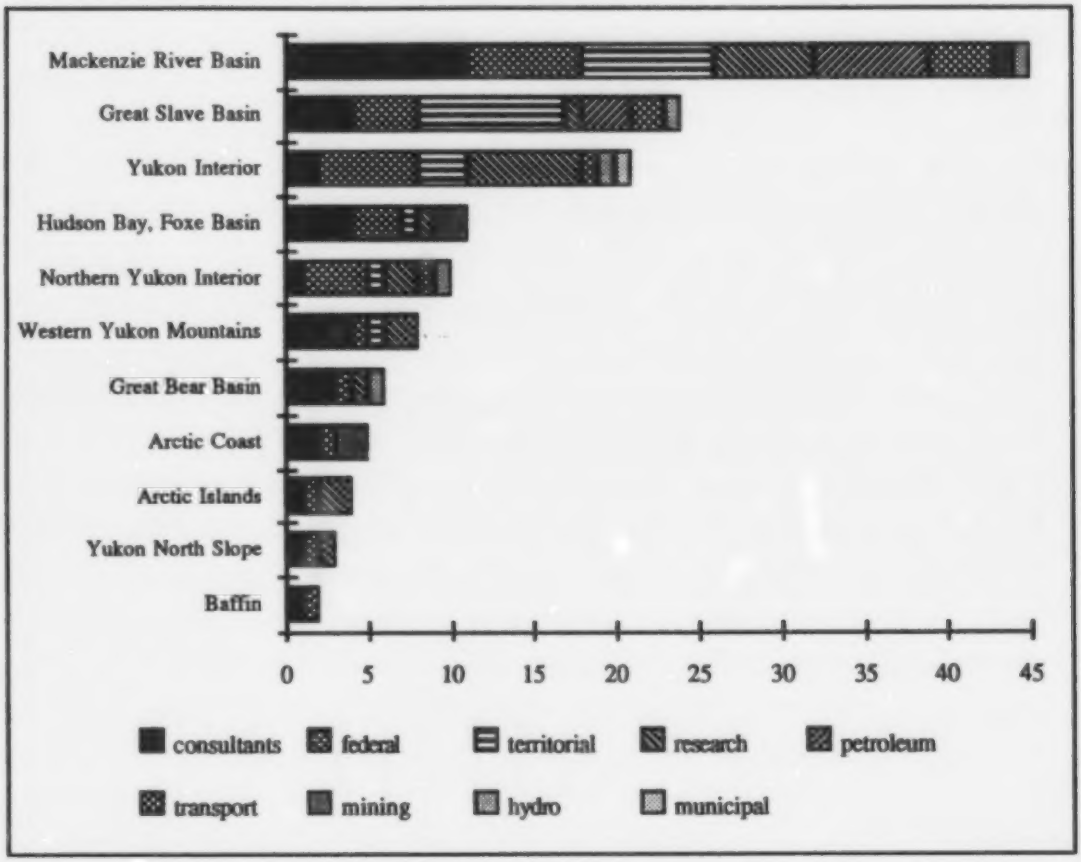

Figure 6: Client groups regional data needs by rank-ordered regions

The hydrometric database was generally considered to be inadequate in terms of network density, especially for data from small streams which were considered to be highly susceptible to impacts from development. The High Arctic and Baffin Island regions, with only two active hydrometric stations near Iqaluit, have obviously the most severe shortage of hydrometric data.

Other under-gauged regions are faced with "...emerging priorities such as land claims issues, transboundary water negotiations, and cumulative impact assessments of industrial developments. Government needs to develop a sound data base on existing water resource conditions that go beyond present network capabilities."

The Yukon database was also thought to be inadequate because of the complexities of hydrologic regimes in a mountainous region.

Other perceived shortfalls in the database were in interjurisdictional systems, in rivers with large flow differences between summer highs and winter lows, and in short-term station density to monitor development 'hot-spots'.

4.1.3 Hydrometric Network Reduction:

Thirty-one respondents, 48%, felt that network reductions would have an adverse impact on their operations. It became clear from many of the survey returns that reductions should be made only after consultation with clients and/or careful examination of alternative strategies which might allow the data collection agencies to remain within budget. The economies of scale were thought to apply to hydrometric networks, i.e., a larger network reduces the per-station cost. Cost should never be the sole criterion to eliminate stations from the network; the value of the data to clients should be the prime consideration. It was felt that a number of data uses would be put in jeopardy by station closures. The uses in jeopardy were:

- optimal engineering design of structures;
- environmental management of sensitive areas;
- loss of ability to extrapolate data to ungauged streams; and
- Canada's participation in international programs; Global Energy and Water Experiment (GEWEX), International Geophysical and Biological Program (IGBP), and Cryospheric Systems (CRYSYS).

Should network reduction become inevitable, the respondents offered a number of suggestions to minimize the impacts. These form the basis for recommendations in Section 7. The suggestions were to:

- develop a 'core' network of priority stations and identify station specifics for short-term dynamic networks through consultation between managers and clients;
- find new partners in cost-share agreements or initiate cost-recovery from specific user industries;
- increase the use of DCP's and other, less-expensive data collection instruments with decreased servicing costs; and to
- review the value of the continued operation of stations with 20+ years of record.

4.1.4 Water Licensees: the User Pay Scenario:

Thirty-five respondents, 55%, felt that water licensees should pay for the data collection costs of their monitoring requirements but there were concerns with the concept. Chief among these were concerns for variable data quality and data inaccuracies which could result. Client suggestions to address these concerns were that:

- the licensees should 'contract' IWD to operate the data collection programs;
- DIAND should rethink their 'regional hydrology' network to include site-specific data requirements;
- the data accuracies required from the license holder should be defined at the outset; and that
- research needs for site abandonment practices should be incorporated in water license data requirements.

4.1.5 Environmental Networks:

Fifty of the 64 respondents, 78%, were in favor of expanded data collection programs to include other environmental factors, but most of the respondents in favour were not prepared to sacrifice the quality or the size of the existing hydrometric program to acquire the additional information. Other data elements suggested were climate, sediment and aquatic contaminants. Six respondents disagreed for a number of reasons. They felt that the suggestion was not timely because of the lack of development in northern Canada; that adding to the complexities already present in the hydrometric program would jeopardize its excellent reputation; and that the hydrometric program was not the right network on which to build an environmental one. Other concerns were:

- organizational difficulties with other government departments; and
- variable siting requirements for non-hydrometric factors which could not be met at existing stations, eg., new climate data in mountainous regions are needed at high elevations and not at low-lying hydrometric stations.

Some of the perceived benefits were:

- a saving in management costs over multi-agency administration of separate networks;

- a larger database, e.g., climate data at hydrometric sites, to facilitate data transfer;
- the use of hydrometric stations in national parks as baseline environmental data stations to 'benchmark' northern development;
- to enhance Canada's participation in the international environmental programs now active in other circumpolar countries; and
- savings in high Arctic logistic costs which dictate that more data than only streamflow be obtained from a site.

In summary, the northern hydrometric network should be carefully screened to identify sites suitable for the measurement of environmental factors other than hydrometric data. Such screening and identification must include participation of other interested or responsible agencies.

5.0 Workshop Reports:

This section contains summaries of the detailed workshop proceedings found in Appendix D and E.

5.1 Yellowknife Workshop, March 05, 1991

The statements which follow reflect the opinions and comments of the workshop participants. Personnel from DIAND Yellowknife and Ottawa, IWD Yellowknife; NWT Chamber of Mines, GNWT Transportation, GNWT Parks and Recreation, GNWT Renewable Resources, NWT Water Board, NHRI, the Science Institute of the NWT and engineering consultants attended. A list of attendees is included with the detailed proceedings.

5.1.1 DIAND Ottawa:

The contract manager's expectations were for inputs to hydrometric network planning to meet the requirements of the Arctic Environmental Strategy. The AES is focussed on emerging northern environmental issues, such as the maintenance of water quality and the promotion of sustainable development of the water resource. Rational plans for the future must consider the integration of water quality and quantity networks, and the need to improve communications between users and planners - hence the survey and workshops.

Initial impetus for development of northern hydrometric networks related to mining development, such as the sites on the Yellowknife River established in the 1930's to facilitate Giant Mines' hydro-electric development. There is great diversity in data needs in today's north, however, and this creates difficulties for modern network design. DIAND's needs are for water management in a developing north. Their management priorities in the NWT are instream uses, community water supply and waste disposal, interjurisdictional water management, recreation, industrial development, highways design, and river basin planning.

5.1.2 DOE Yellowknife:

DOE's requirements from the northern network are for a characterization of the size and distribution of the freshwater resource. There exists also a mutual data need for DOE and DIAND for flood damage reduction programs and for the management of water transportation systems and interjurisdictional rivers. Analysis of specific uses for individual site data in the

DIAND water management network (Wedel, 1991) suggests that most stations in the NWT network are multi-purpose.

5.1.3 Preliminary Survey Results:

Workshop discussions of the preliminary survey results and the data request log analysis emphasized that:

- federal agencies were the largest users of hydrometric data;
- native organizations, who did not respond to the survey or to workshop invitations, will eventually need to deal with interjurisdictional water management;
- the petroleum industry water data needs relate to two main issues - river crossing design for pipelines and spill management;
- the mining industry needs data, generally of a site-specific nature, to manage industrial water use and waste disposal;
- transportation (highways) needs data for bridge and culvert design on new roads and for managing ferry operations;
- foreseeable hydro-electric data requirements are for the design of small-scale hydro plants to service isolated communities now using diesel generation;
- consultants are major users of hydrometric data; their products provide analysis and advice for most northern development;
- academics use hydrometric data as teaching tools, and in research projects; and that
- the general public who use data in non-scientific ways, e.g., canoeists, are not being provided with water information in a useful form.

5.1.4 User Survey Results Discussion:

The topics addressed in the user survey, presented here in Section 4, were reviewed at the workshop. See Appendix C for greater detailed results of the user survey.

Commentary on the development of environmental networks generated lively discussion but no consensus. The session reflected the diversity of opinion received in the mailed responses. One main concern was the potential for the dilution of an existing good product currently generated by the Water Survey of Canada. Other concerns were with site compatibility among disciplines, the complexities of joint planning, and with the kinds of data to be collected. A key comment was that the NWT, still largely undeveloped, has an

opportunity to prevent major environmental pollution at the outset. This desirable goal could be achieved by application of southern experience to northern development, and from the growing understanding of physical processes in the northern environment.

5.1.5 WRD Yellowknife:

An historical overview was presented to put the existing hydrometric network regime in the departmental, water management context.

DIAND's Water Resources Division and DOE's Inland Waters Directorate were the same organization in the late 1950's and early sixties, before IWD became an agency of the federal Department of Energy, Mines and Resources. The name of the common department was Northern Affairs and National Resources. In the pre-1975 era, this common agency bore all costs associated with hydrometric network operation in the north. The formal agreement of 1975 created three main classes of stations in terms of funding: 100% federal, those shared 50-50, and 100% territorial stations. Territorial responsibilities, including funding, was then and continues to be borne by DIAND.

Operational costs continued to rise throughout the last decade. Figure 7, extracted from the NWT 1989-90 DIAND-DOE annual report (1990) illustrates the rate of increase.

In 1990-91, two stations were discontinued and one of two winter field trips for the NWT region was dropped because of financial constraint. As a result, the reliability of mid-winter low-flow data has decreased, although the impact has been lessened somewhat by the use, where possible, of re-transmitted digital (DCP) data in place of lost analog records.

DIAND priorities for the NWT water management program, listed earlier, elicited workshop comments about their use in network planning. Chief among these were that:

- priorities could change dramatically, and should therefore be used with caution in network design;
- stations should contribute to priority elements to justify funding from DIAND;
- changing priorities contribute to network dynamics; funding should be set aside to accomplish necessary changes to the network; and that
- instream uses, while ubiquitous, might nevertheless have a bearing on the precise siting of new stations.

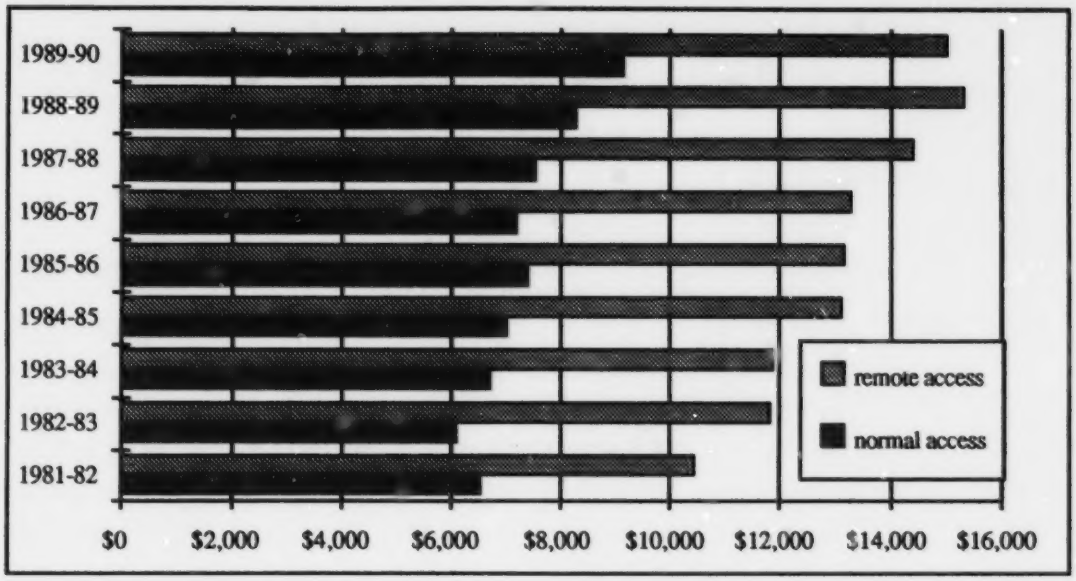

Figure 7: Increase in operational costs of WSC operations in the NWT

Future trends in network development are uncertain, given the expected influx of resources from the AES, but network funding from A-base resources will likely be reduced. New funding sources from other branches and agencies might accrue to environmental stations designed to collect data other than just streamflow and water level.

5.1.6 The Research Community:

The research agencies suggested that hydrometric station location may be significant, but the questions of what needs to be done, and when, are equally important. For example, water levels and sediment flux, not streamflow, are critical data in ice-jam floods and have significant environmental consequences. The spring breakup on some north-flowing rivers is considered to be the major biological event of the year since it controls riverbank characteristics and its vegetation, and therefore the biological communities living there.

Researchers were also concerned about poor streamflow data in other periods affected by ice, about the non-existent Arctic Islands database, and about the increasing pressure on northern water resources from development for municipal water supply, hydro-power, river diversions, and from the mining and hydrocarbon industries.

Northern water resource programs need to be linked to the issues of climate change, to long-range transport of pollutants, to other elements in the hydrologic cycle such as snowfall and evaporation, and to international programs such as CRYSYS and GEWEX. Global climate change will generate a decrease in arctic ice cover, will change wetland and permafrost regimes, and create a rise in mean sea level.

The establishment of remote climate sensors at physically-suitable, regional hydrology stations was suggested, as was the development of linkages between snowmelt models and groundwater regimes in regions of permafrost. Linkages between snowmelt and groundwater could be developed by documenting seasonal active layer development at existing snow courses.

Although the Mackenzie Basin continues to be the major focus for research, other basins in northern Canada should at the very least, be characterized for hydrologic response and water quality and to have the linkages between these parameters and physical basin characteristics developed.

5.1.7 Engineering Consultants:

Engineering consultants stressed the economic benefits of site-specific hydrometric data, and failing that, the worth of regional data. A $200K saving in the initial cost estimates for the Yellowknife Bay marina was realized from efficient design of channel depths and breakwater height, made possible by consideration of the long-term water level record for Great Slave Lake. Structures are built with or without hydrometric data, but in their absence, designs are conservative and the costs greater.

Follow-up comments suggested that joint network planning should include information needs identified in the GNWT Five-Year Capital Plan, that good regional water resource models be designed, that improvements to the groundwater database be made, and that advertising of the water resources data be improved.

5.1.8 IWD Yellowknife:

In keeping with the last comment, IWD announced a new drive to advertise water resource products. Initiatives for 1991-92 include the publication of a Nahanni River Basin

Overview, and the preparation of interpretive reports, fact sheets, newspaper articles, and public-area bulletin boards. Water data for the NWT will be made available from all local IWD offices; in Yellowknife, Inuvik, Fort Simpson and Fort Smith.

An IWD hydrometric station evaluation project, in progress, for all federal stations in the NWT, is designed to complement the recently-completed DIAND station review. Some initial products are a new network database in Lotus 123; detailed, integrated station profiles; and the development of a revised set of federal priorities. A future need is to generate an holistic evaluation of the entire network by integrating the DIAND report with the IWD study.

IWD has reached an agreement for the deployment of Atmospheric Environment Service (AES) climate sensors at selected hydrometric stations. Two are now in place; four additional stations are to be installed in 1991.

5.1.9 Mining Industry:

According to the mining industry, concerns with high network operating costs, while real, needed to be put in the perspective of environmental data collection programs now required from the industry. For example, the environmental data collection and monitoring costs for one mining company, Giant Yellowknife, were greater than the cost of the total hydrometric program in the NWT. Mining companies now collect significant quantities of environmental data, at high cost, in all phases of their activity. Co-operative ventures, as in the case of Nerco, DIAND and DOE who now cost-share three hydrometric stations, are welcomed. Better communication at the network planning stages between the NWT Chamber of Mines and DIAND/DOE could resolve related concerns such as network flexibility, at the outset. It was stated that all NWT mines have recently made commitments to minimize environmental damage, notwithstanding the high cost of environmental data collection programs.

5.1.10 Transportation Systems:

Transportation systems need hydrometric data for ferry crossings on major NWT highways, for the design of river crossings on new highways in the NWT, and for marine facilities. GNWT Transportation has assumed responsibility for roads and ferry operations from DIAND and spends $37 million annually to maintain and improve current facilities. Joint

venture proposals to make operations more cost-effective would be welcomed. A number of major highway projects which will need river-crossing design information, are in various planning stages. Of these, the Yellowknife-Bathurst Inlet link, a Mackenzie Valley highway, and the re-alignment of the Yellowknife-Fort Providence highway are the most advanced.

Open-water river stage forecasts are vital to safe, economic ferry operations and breakup forecasts could lengthen the ferry operational season at Fort Providence. GNWT Transportation can provide data for ice growth collected during ice-road construction and maintenance.

Other concerns of GNWT Transportation were with the impact of increasing sea levels on marine facilities and the monitoring of contaminant spills at ferry crossings.

5.1.11 General Discussion:

The concept of master-slave stations in a hydrometric network was discussed. A 'master-station' network of 30-50 stations was suggested to form the basis for regional hydrologic extrapolation aided by data from short-term satellite stations. Master stations would be candidates for a multi-disciplinary, integrated network. The dynamic nature of the satellite station network could provide managers with the flexibility needed to address project-specific information requirements.

Planning an environmental network requires the definition of specific regions based on hydrology, climate, geology, vegetation and land-use. A co-ordinating group needs to be established to exchange information and to unify network planning among participating agencies.

The workshop discussions of environmental networks developed two suggestions for future management. They were that:

- 'master stations' need to be defined in the context of unique hydrologic regions as a first step in the design of an environmental network; and that
- an environmental network planning committee needs to be established in the NWT to integrate the multi-agency program.

5.1.12 Data Needs by Industry:

Data or information needs by industry were identified by workshop participants and are shown in Table 2.

Table 2: Information Needs by Industry Identified in Yellowknife Workshop

	Mines	Roads	Marine	Hydro-electricity	Oil and Gas	Recreation	Communities	Instream Uses
precipitation	*			*				
evaporation	*			*				
snow	*			*				
icings		*		*	*			
ice jam site studies			*	*	*		*	
ice runs			*		*		*	
ice scour					*			
daily flow				*		*		*
daily water level			*	*		*	*	*
maximum flow	*			*	*		*	*
design flows		*		*	*		*	
maximum water level		*					*	*
minimum freezeup water levels			*					
24 hr. flow/level forecast		*	*					
long-term flow forecasts				*	*	*		
flood forecasts		*	*			*	*	
breakup/freezeup forecasts or dates						*	*	
velocity		*	*	*	*	*	*	
minimum flow	*					*	*	*
groundwater	*				*		*	*
water quality	*		*		*	*	*	*
biota	*				*			*
habitat	*				*			*
water temperatures	*			*		*		
sediment flux	*			*	*		*	
sediment quality	*			*	*			*
channel morphology				*	*			
migratory bird habitat	*			*	*			*

5.2 Whitehorse Workshop, March 7, 1991

5.2.1 WRD Whitehorse

The first hydrometric network in Yukon developed in response to site-specific information requests for navigation, hydro-electric and mining development. Gradually it became a baseline data network. As in the NWT, 1975 marked the year of formal agreement between DOE and DIAND to operate hydrometric stations in Yukon. The initial co-ordinated network, of 37 stations, grew to 52 stations in the five years following. Northern Canada Power Commission, now Yukon Electric, became party to the agreement for network management in 1979, with the beginning of a second five-year plan, and the network expanded to 73 stations. No-growth budgets and escalating costs in recent years have adversely affected network management and damaged product delivery. Continued program support at existing operational levels is not possible.

Priorities for network reduction were developed from analysis of individual station profiles (McFarland, et al, 1988). The preferred option to meet a $30K deficit in 1990-91 was to discontinue 25 to 35% of the existing network in northern Yukon. It was not implemented because of a management decision to cover the shortfall, but the funding crisis remains.

A suggestion that operational economies might be derived from joint operations of water quantity and quality networks was not considered to be effective for the present Yukon networks since only five water quality stations are operational in Yukon.

The pending Yukon Water Quality Agreement focusses on development of a long-term baseline water quality network to sample 'normal' or traditional parameters. Emerging needs, however, are for data on organo-chlorines and biological contaminants. The high cost of such programs could be accommodated if the regional water quality program adopted a 'recurrent' sampling approach to sample regional characteristics as periodic 'snapshots'. Yukon water quality could be characterized in this manner for 1/3 of the proposed budget dollars.

Two ongoing problems with the items in the proposed Water Quality Agreement are the exclusion of northern, unglaciated catchments from the network, and the lack of approval for the recurrent sampling scheme.

5.2.2 IWD Vancouver:

Historical background and hydrological summary data for the Yukon hydrometric network were provided from the federal perspective:

- 1700-1800 station years of hydrometric data, available as daily flows and statistical summaries, have been accumulated for Yukon.
- Of the present 74 stations, 63 are streamflow stations. The remaining 11 are water level only stations. Of the 63 streamflow stations, 38 now have 15 years of record and 22 have record length greater than 15 years. Streamflow station density is approximately one station for every 8000 km^2 , a reasonable value overall, but, according to survey returns, the density of stations on catchments < 500 km^2 is not adequate. DIAND has historically operated a number of small-catchment stations in the short term, then turned some of them over to WSC for long-term operation.
- One-half the streamflow stations are located in basins with catchments < 6000 km^2.
- 88% of the Yukon landmass is now gauged. This provides reasonably good information about total freshwater discharge to the sea or, alternatively, average annual runoff per square km.
- Water Survey of Canada is re-structuring to combine water quantity and quality programs into a new, environmental surveys group.

5.2.3 DFO Whitehorse:

From the fisheries perspective, improved information is required for mid-winter flows in creeks which serve as over-wintering systems for salmon. The problem derives from the standardized listing of zero-flow on creeks which maintain good baseflow through coarse bed materials. Licences have been granted for instream development on the premise that the published zero-flow condition precluded salmon usage of the system. Consultants hired by developers tend to use WSC data and their sampling sites. The net result is an on-going disagreement between fisheries biologists on the one hand, and the WSC and engineering consultants on the other. It was suggested that the engineering bias of the WSC program tended to diminish the biological necessities of accurate low-flow monitoring in winter, a regime vital to fish populations. Also of concern were the impacts of industrial effluent discharges in the winter and their severe biological impacts in the low flow period.

A new flow category, 'Water flow present but unmeasurable', was suggested by WSC, who also agreed that protection of riverine biology was of top priority. Downstream dilution models, such as RIVMIX, could be used on a monthly basis to assess impacts of pollutants if flows could be determined with sufficient accuracy.

Water Survey of Canada should institute a new labelling convention to describe streamflow through coarse bed materials when no surface flow is evident. New flow category: 'Flow present but unmeasurable'.

5.2.4 WSC Vancouver:

Water Survey of Canada can supply unconventional data on a variety of media if requested, but often users do not know of its availability. Data types are:

- water levels at streamflow stations;
- ice thickness from discharge measurement survey notes;
- water temperatures from WSC survey notes;
- short periods of unpublished, continuous streamflow data;
- sediment data for Yukon, generally sparse and of short duration. A sediment transport model is in development to assess effects of placer mining on rivers. Its development is being delayed by the lack of calibration data; and
- real-time data, needed for management of water licences. These, however, present verification problems and their preliminary nature must be emphasized. Such data can only be used as indicators of trends, not as absolute values.

5.2.5 WRD Whitehorse:

Yukon water resources staff of WRD, DIAND suggested that a realistic division of Yukon into four regions, based on hydrologic elements, could be used to classify survey returns. The four regions, interior, western mountain, northern interior, and arctic, were distinct by annual hydrograph shape, and had been derived statistically from correlation, cluster and discriminant analysis. These regional divisions were supported by differences in permafrost environments.

5.2.6 City of Whitehorse:

The City of Whitehorse has measured inlet water temperatures from the 1970's and potability data for periods from one to five years depending upon the parameters sought. The lack of other data for potability of surface waters in Yukon was attributed to the almost universal use of groundwater for domestic use. There is not at present, an active program in Yukon to assess surface water potability.

5.2.7 The Research Community:

Many of the research concerns discussed were common to both workshops.and are therefore not repeated. Comments specific to hydrologic research in Yukon follow.

The impacts from global warming need to be addressed in the context of northern water resources. Some expected changes and their impact on Yukon hydrology were that:

- atmospheric moisture levels will rise and consequently, increase orographic precipitation in northern mountains. Response of Yukon glaciers to more snow is unknown as is the surface water hydrologic response;
- the impact of a warmer climate on regions of discontinuous permafrost and therefore on the groundwater regime could be significant, especially in Yukon which makes use of groundwater for potable water supply; and though
- the Canadian focus for international programs will likely be the Mackenzie Basin in the NWT, the Peel and Liard basins in Yukon are tributaries and Canada's participation in these international programs therefore has implications for Yukon data programs.

5.2.8 Yukon Electric Company Ltd.:

New strategies and data programs were needed by others as well. For example, Yukon Electric needs to determine water losses from wetlands and through groundwater systems for impact studies on behalf of fisheries and land use planners, and to derive the total energy potential of a river system.

Yukon Electric is conducting site evaluations for the establishment of small-scale hydro plants on a number of ungauged rivers in Yukon. Because of the difficulty in deriving

correlation data from long-term hydrometric stations in mountainous terrain, the utility is operating a miscellaneous measurement program at 15 sites. Their chief interest in conventional data is for low-flow periods. Much of the data now required by Yukon Electric have already been gathered by other studies, e.g., by the mining industry.

A 'non-conventional' data bank to accumulate privately-gathered, design-level data should be established.

For their on-going field surveys, Yukon Electric was advised to use solid-state instruments to keep pace with WSC procedures. The new instruments would also enable the utility to sample other environmental data.

5.3.9 General Discussion:

In subsequent discussion, the inclusion of special-project, short-term stations in the hydrometric network was criticized on economic grounds. It was stated that the DIAND Northern Affairs Program has the ability to operate short-term, site-specific, project-oriented studies at a fraction of the costs associated with a WSC program. As a counter argument, the concept of a baseline network to operate in the long-term, complemented with short-term project-specific network stations was suggested to keep the site-specific data in the public domain and of acceptable quality. They could then be used for hydrologic regionalization to minimize future site-specific data requirements.

A further comment, also on economics, concerned the overall cost of hydrometric data acquisition in Yukon, which now consumes one-half the annual budget of the Water Resources Division, Northern Affairs Program, Yukon. There was a concern with proposals that cost more money with no increase in network size. Money could be saved by reducing data quality, (not agreed to), or by collapsing the Yukon hydrometric network to core stations; the monies thus freed could be used to implement new programs such as those suggested by the research community.

Clearly, the levels of current funding and Northern Affairs Program's other needs are constraints on hydrometric network operations. Other alternatives for funding such as Atmospheric Environment Service's support for climate stations are needed.

5.2.10 Specific user group data needs:

The final session of the day identified data requirements from the perspective of individual user groups. This involved a level of role-playing, since many of the user groups were not present. The suggestions received from the workshop are summarized in Table 3.

5.3 Conclusions Reached by the Workshops:

Client needs for water resources information identified in the course of the mailed survey and these workshops will be provided to the NWT and Yukon Hydrometric Coordinating Committees and their administrators. It was also noted that:

- this information and hydrometric data in general must become more accessible and be made known more widely;
- a beginning must be made to collect data to deal with climate change and arctic contamination, e.g., snow water quality. These must be identified as new activities to departmental planners;
- a decision must be made about what the northern water resource network will look like over the next 20 years;
- the water resource management issues posed by new developments must be identified as must the contribution of the hydrometric program toward their resolution; and that
- DIAND and IWD must improve communications with their users and must adapt their water data programs to meet user needs;

Table 3: Information Needs by User Groups Identified in Whitehorse Workshop

	Mines	Linear Devesopments	Research	Consultants	Hydro-electricity	Recreation	Communities	Instream Uses
precipitation	*			*	*			
evaporation	*		*	*	*			
snow	*		*	*	*			
glacier ice core data			*	*				
icings		*		*	*			
ice jam site studies				*	*			
ice runs				*	*			
ice scour				*	*			
daily flow	*		*	*	*	*	*	*
daily water level	*	*		*	*	*		*
maximum flow	*	*	*	*	*			*
long-term data trends			*	*		*		
design flows				*	*			
annual runoff volume			*	*				
maximum water level				*				*
minimum freezeup water levels				*				
24 hr. flow/level forecast				*		*		
long-term flow forecasts				*		*		*
flood forecasts				*				*
breakup/freezeup forecasts or dates				*				
velocity				*				*
minimum flow				*				*
groundwater	*		*	*			*	*
water quality	*			*	*	*	*	*
biota				*				*
habitat				*				
water temperatures			*	*	*		*	*
sediment flux	*	*		*	*	*		
permafrost		*		*				
sediment quality				*				*
channel morphology		*		*				
migratory bird habitat				*				

6.0 IWD Yellowknife Data Request Logs - Analysis

In total, 267 requests for hydrometric data were officially logged by IWD in the period, 1988-90. There is some question about how accurately this listing reflects total data dissemination. It is known, for example, that Nerco-Con Mine obtains daily water resource information by private access to Yellowknife River Basin gauges at locations critical to their operations. Mackenzie River flow forecasts are also distributed daily to navigation agencies via TELEX. It is highly likely also, that much streamflow data is disseminated through casual, person-to-person contacts between IWD staff and clients that are not entered as formal data requests. Finally, many of the requests come from clients who require information for the previous year before the release of data publications. This probably biases the following analyses towards clients who require the latest data for design purposes or for water resources-related planning in other government agencies. Reservations aside, the statistics available from the formal data log create an independent perception of water resource data use by client category and by data types.

The obvious question which arises is how the data request log data compares with the results from the user survey, described in Section 4. This may be answered in part by the analysis shown in Figure 8, a comparison of client fractions from both sources.

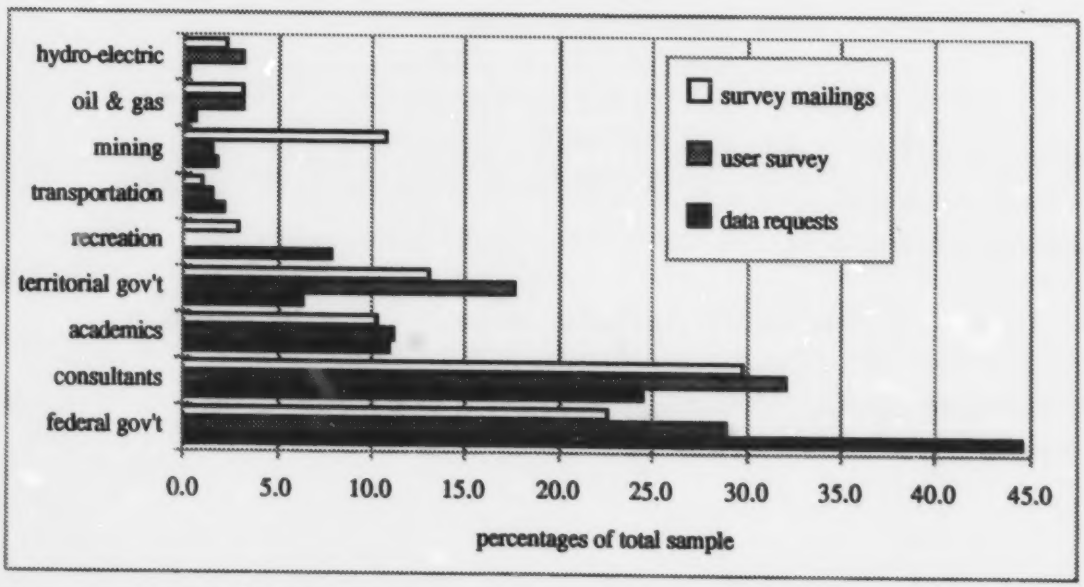

Figure 8: Comparison of client group fractions in survey mailings, n = 211; survey responses, n= 64; and in the WSC Yellowknife data request logs, n= 267

The comparison in Figure 8 shows that the general trend of distribution between client groups remains similar for the three data sets, but that specific fractions may vary considerably, For example, there is large variation in the fraction of federal agencies in the three samples, varying between 45 % of the data request sample and 22 % of the survey mailing. Greatest uniformity of sample fractions is noted for the research-academic user group.

Many of the data requests, 84 of 267, identified the activity which gave rise to the request. For these 84 requests, analysis was therefore possible to relate the activity to number of requests. This is shown in Figure 9.

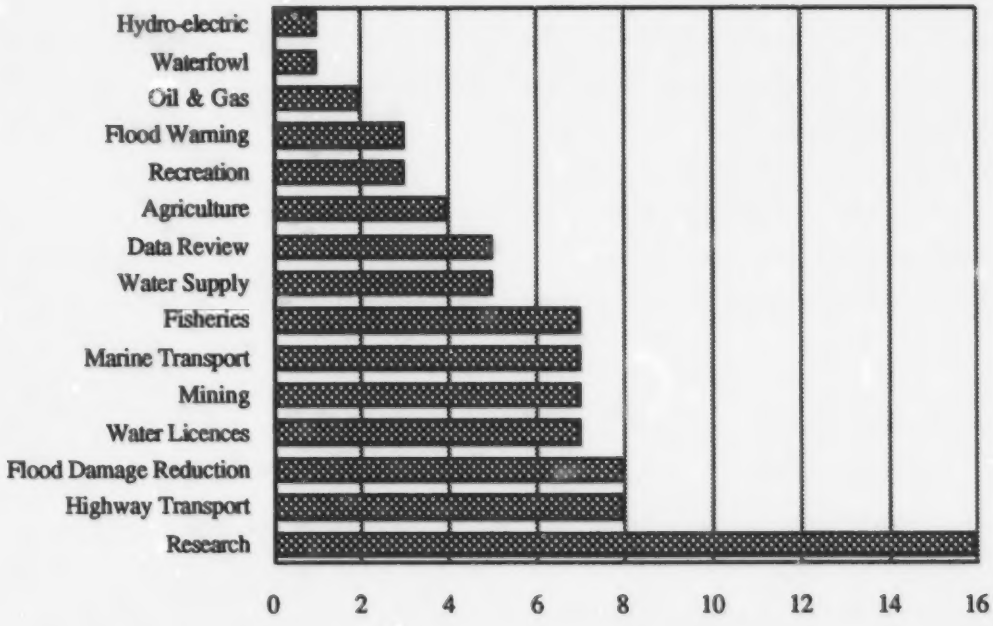

Figure 9: Data requests classified by activity, n = 84 of 267 requests

It was also possible to classify the kinds of data requested. The analysis of data requests by type is shown in Figure 10.

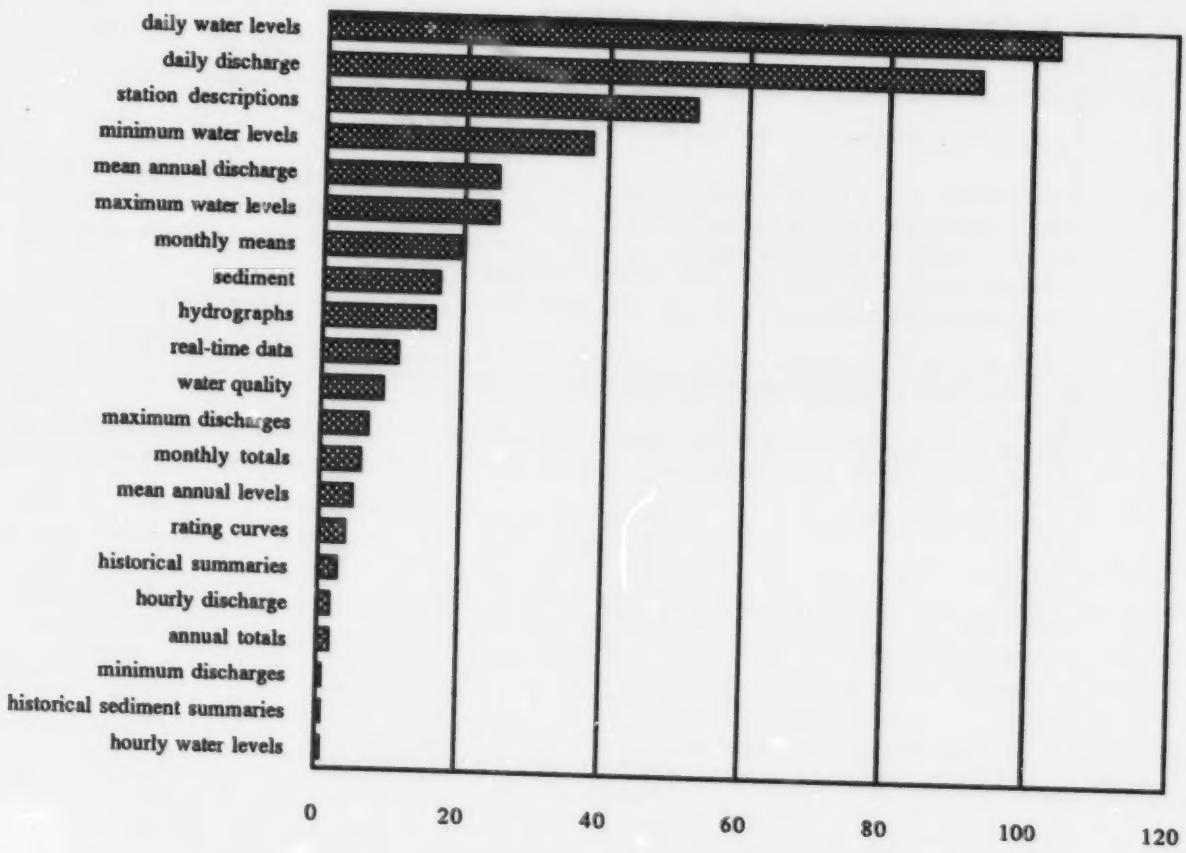

Figure 10: Data log requests analyzed by data type, n = 267

Summarized results are presented in Table 4. It classifies data requests for individual stations by data type and by user category. A final analysis, shown in Table 5, summarizes the data requests by type, relates each type to the number of requests in the three-year period, and links the data type to DIAND priorities in the NWT.

Data request logs are sufficiently valuable as a surrogate user survey that they should be maintained in WSC offices in both Yellowknife and Whitehorse, preferably on electronic media.

Table 4: Yellowknife Data User Log Summary

Code listings for data types requested from Yellowknife IWD Office:

1-daily discharge, 2-daily water levels, 3-monthly totals, 4-monthly means, 5-annual totals, 6-max.water level, 7-min.water level, 8-sediment, 9-rating curves, 10-mean annual discharge, 11-hourly water levels, 13-water quality, 14-station descriptions, 15-real-time data, 16-mean levels, 17-mean annual discharges, 18-hydrographs, 19-historical summaries, 22-maximum discharges

Code listings for user categories requesting data from IWD Yellowknife

1-federal, 2-territorial, 8-oil & gas, 9-mining, 11-hydro-electric, 12-consultants, 13-academics, 14-research

Station Name	Number of Requests	Data Types Requested	User Categories	Station Number
Mackenzie R. at Norman Wells	17	1,2,6,8,14,15	1,8,12,13	10KA001
Mackenzie River @ Arctic Red River	16	1,2,8,10,14,15,18	1,2,12,13	10LC014
Great Slave Lake at Yellowknife Bay	11	1,2,4,6,7,8,18,19	1,2,12	07SB001
Mackenzie River(E. Channel) at Inuvik	10	1,2,8,9,14,15,16	1,8,12,13	10LC002
Indin River above Chalco Lake	9	1,4,9,10,14,15	1,2,11,12,14	07SA004
Mackenzie River at Fort Simpson	9	1,2,8,10,14,18	1,2,12,13,14	10GC001
Hay River near Hay River	8	1,2,4,6,7,11,18,21	1,12,13	07OB001
Liard River at Fort Liard	7	1,2,3,4,6,7,8,14,16	1,9,12	10ED001
Liard River near the mouth	7	1,2,8,10	1,12	10ED002
Peace River at Peace Point	6	1,2,9	1,2,12	07KC001
Slave River @Fitzgerald	5	1,2,6,8,10	1,12	07NB001
Cameron River below Reid Lake	5	1,4,14,16	1,12,14	07SB010
Talston River at outlet of Tsu Lake	4	1,2,6,18,19	1,2,12	07QA001
Nanacho Lake near Snowdrift	4	2,6,14,15	1,12	07QD002
Snare River below Ghost River	4	1,14,15	1,2,12,14	07SA002
Trout R. at Mackenzie Hwy	4	2,14,17	1,2	10FA002
Jean-Marie R. at Mack. Hwy	4	1,2,14,17,18	1,2,12	10FB005
Peel River above Fort McPherson	4	1,2	1,10,12,13	10MC002
Firth River near the mouth	4	1,2,18	1,12,13	10MD001
Anigaq River below Audra Lake	3	1,3,4,14,18	9,12	06MA007
Dianna River near Rankin Inlet	3	1,2	1	06NC001
Little Buffalo River below Hwy. 5	3	1,2,3,4,6,7,18,22	1,12	07PB002
Yellowknife R. at outlet from Prosperous L.	3	1,4	1,12	07SB002
S. Nahanni above Virginia Falls	3	1,2,4,6,7	1,12,13	10EB001
Mackenzie River at Fort Providence	3	1,2,8,15	1,14	10FB001
Martin R. at Hwy #1	3	1,2,5,8,14,17	1	10GC003
Redstone River near the mouth	3	1,2	12,14	10HB005

Table 4 Cont'd

Station Name	Number of Requests	Data Types Requested	User Categories	Station Number
Mackenzie River near Wrigley	3	2,6,15,22	1,10	10HC001
Mackenzie River above Arctic Red River	3	1,2,14	1	10LA003
Babbage River	3	1,2,18	1,12	10MD002
Coppermine River below Copper Creek	3	1,14,10	1,13	10PC004
Thlewiaza River at Seal Hole Lake	2	2,10,14	13,14	06HB002
Tha-Anne River below Roseblade L.	2	10,14	13	06HB001
Qinguq Creek near Baker Lake	2	1,3,4,14,18	9,12	06MA002
Thelon River below Shultz Lake	2	1,14,18	12,14	06MA006
Kakisa River	2	1,2,3,4,6,7,22	12	07HC001
Dog River near Fitzgerald	2	18,19	1,2	07NB008
Hay River near Alta/NWT Boundary	2	1,2	13	07OB008
Duncan Lake	2	2	9,14	07SB012
Baker Creek at outlet of lower Martin Lake	2	1,14	12,14	07SB013
Kakisa River at outlet of Kakisa Lake	2	1,2,4,6,7	1,13	07UC001
Rabbit Creek at Hwy 7	2	14,17,18	1	10ED006
Willowlake R. below Metahdali Creek	2	6,22	10,12	10GB001
Harris River near the mouth	2	14,17,18	1,12	10GC002
Sahndaa Cr. near Mack. Hwy	2	2,5,14,17	1	10GC005
Twitya River near the Mouth	2	1,2,6,7	12,14	10HA003
Great Bear L. at Ft. Franklin	2	2,14,16	1,2	10JA001
Mackenzie R. (Middle Channel) Tununuk Pt.	2	1,2,8	1	10LC012
Anderson River	2	1,10,14	1,13	10NC001
Back River below Beechy Lake	2	2,10	12,14	10RA001
Big River above Egg River	2	1,14	1	10TH001
Kognak River	1	10,14	13	06HD001
Hanbury River at Hoare Lake	1	14	14	06JB001
Thelon River above Beverly Lake	1	14	14	06JC002
Dubawnt Lake	1	2,14	1	06KC002
Ennadai Lake	1	2,14	1	06LA002
Baker Lake at Baker Lake	1	13,16	2	06MA001
Slave River at Bell Rock	1	6	1	07NB003
Snowdrift R. at outlet Siltaza L.	1	6	1	07QB002
Talston R. above Porter L. outflow	1	1,6	1	07QD004
Porter Lake outflow	1	6	1	07QD006
Lockhart River at outlet of Artillery Lake	1	1,4,6,7	13	07RD001
Wecho River	1	14	14	07SA005
Yellowknife River at Inlet to Prosperous L.	1	4	1	07SB003
Prosperous Lake near Yellowknife	1	14	14	07SB014
Mac Creek near the mouth	1	1	12	10EB002
Lened Creek above Little Nahanni River	1	1	12	10EB003
South Nahanni River at Clausen Cr.	1	2	12	10EC001

Table 4 Cont'd

Station Name	Number of Requests	Data Types Requested	User Categories	Station Number
Birch River at Hwy 7	1	14,17	1	10ED003
Mackenzie River at McGern Island	1	2	10	10GB003
Mackenzie River at Km 518	1	2	10	10GB004
Willowlake R. above Methadali R.	1	17	1	10GB006
Mackenzie River above Liard River	1	8	2	10GC004
Acasta River above Little Crapeau Lake	1	1,2	12	10JA004
Johnny Hoe River	1	1,2	12	10JB001
Great Bear L. at Radium	1	2,14	1	10JC002
Great Bear R. at Great Bear Lake	1	1,3,4,5,6,7,9	2	10JC003
Great Bear L. at Hornby Bay	1	2,14	1	10JE002
Little Keele	1	6,7	14	10KB001
Mountain River	1	2	14	10KC001
Mackenzie River at Sans Sault Rapids	1	15	1	10KD001
Arctic Red River	1	1	12	10LA002
Weldon River	1	1,2	12	10LA004
Mack. R. E. Channel near Reindeer Depot	1	2,14	1	10LC001
Mack. R. Middle Ch. above Napoiak Channel	1	1,2,14	1	10LC008
Mackenzie R. (E. Channel) Kittigazuit Bay	1	2	1	10LC013
Mackenzie R., Peel Ch. at Aklavik	1	2,14	1	10MC001
Mackenzie R. W. Ch. below Aklavik Channel	1	1,2,14	1	10MC004
Rat River	1	1,2	12	10MC007
MacKenzie R. (Reindeer Is.) Ellice Island	1	2	1	10MC011
Burnside River Near the mouth	1	2	14	10QC001
Baillie River near the mouth	1	2	14	10RA002
Back River above Herman R.	1	2	14	10RC001
Duval River near Pangnirtung	1	1,14	1	10VF001
Sylvia Grinnell River near Iqaluit	1	1,4,22	12	10VH001

Table 5: Extracted Uses from Yellowknife Data Request Logs

Purpose of data requests	No. of Times Identified in Yellowknife Request Log	Relates to INAC WRD Priority
flood study	13	2,5,6,7
marine transport	13	1,6
mining development	9	5,7
storm event tracking	8	7
fisheries	6	1
hydro-electricity	6	5,7
data review	5	
community water supply	5	2
new bridge design	4	6
ranching feasibility study	4	7
bed load transport	3	1
NWT water licence	2	2,7
climate station locations	2	7
low flow analysis	2	2
recreation	2	4
heat transfer study	2	
limnology study	1	1
oil production	1	5
water loss research	1	3
bird colonies	1	1
time of travel studies	1	3

DIAND Priorities

1 instream
2 community needs
3 interjurisdictional
4 recreation
5 industrial dev.
6 highways
7 basin planning

7.0 Conclusions:

The responses obtained from this user survey had much in common with earlier Canadian surveys of hydrometric data users. Common items identified included the need for better data in ice periods, more stations on small catchments to develop better data transfer capability, more extensive interpretive reporting, more water quality and sediment data, and ill-defined data evaluation techniques. The surveys, collectively, also identified similar user activities, such as highways engineering, community water supply and waste disposal, interjurisdictional water management, recreation and research into the fundamental character of a region's hydrology.

The value of the hydrometric data from a network station cannot be assessed by consideration of only the uses which are identified in funding agreements. There are invariably a host of other, unidentified uses for these data. This fact poses problems for program planners and administrators.

Sections four, five and six of this report contain much useful information for northern hydrometric network management. Responses from clients in the survey replies and workshop comments were detailed and instructive. They derived from a variety of concerns with the hydrometric databank and with the program. Details follow, with appropriate recommendations to program administrators.

Based on the analysis in Figure 5, page 19, more than half the respondents supported the concept of expansion of the hydrometric network into an environmental one; the user-pay concept; and the need for better data at more stations. The use of electronic media for hydrometric data dissemination was generally accepted as the wave of the future, although many users, while conceding this, felt that there remained a place for paper data books, provided their legibility were improved. The use of CD-ROM data disks or of real-time data has not yet gained wide acceptance; data formats appeared to be at least part of the reason.

7.1 Recommendations:

The legibility of recent hard-copy data was frequently criticized, as was the binding of individual reports.

Recommendation

IWD should correct the poor quality of recent data publications.

Many respondents felt that electronic media were the wave of the future. A number of large organizations already owned CD-ROM readers, but many would prefer to receive data formatted for popular spreadsheet programs on personal computers. There was widespread concern for the small user or for new clients not equipped to handle electronic data.

It was apparent that a number of 'growing pains' were still associated with electronic media data distribution. Whitehorse offices of WSC or WRD need a CD-ROM reader!

Recommendation:

The northern offices of IWD and WRD should acquire the necessary computer hardware and software to supply clients with hydrologic data in a variety of formats, e.g., CD-ROM, popular PC spreadsheets, ASCII.

A number of clients were not aware of ancillary survey data for water temperature, ice thickness, river velocity.

Recommendation:

IWD and DIAND should institute an ongoing advertising campaign to create client awareness of ancillary hydrologic data available in IWD and WRD offices.

The concept of environmental networks was seen as a difficult one to manage from an operational viewpoint. Hydrometric stations frequently are not suitable to collect other related data for water quality, sediment, and climate, although the usefulness of streamflow data

collected in conjunction with these other data sets was well understood and acknowledged in both the user survey and the workshops.

Part of the problem with environmental networks is the lack of definition of the term. It has been implicit in this study that a water-related environmental network would acquire data for streamflow, water quality, sediment and climate. There is a feeling derived from comments at the workshops, that this definition might be too narrow and should contain some ecological component.

Recommendation:

Water resource managers and data users should jointly define the term: environmental water resource network.

There were a number of significant shortcomings in the existing hydrometric database that need to be addressed. These include better definition of the mid-winter low-flow regime, especially in Yukon small river systems that overwinter salmon; inadequate spring breakup flow data because conventional measurement techniques cannot be used; and data loss from instrument failure. To correct the first two problems,

Recommendation:

Water Survey of Canada should institute a new labelling convention to describe streamflow through coarse bed materials when no surface flow is evident. New flow category suggested is 'Flow present but unmeasurable'.

Recommendation:

New techniques should be developed or adopted by WSC to obtain water level and flow data during the spring breakup.

The financial constraints imposed on the rational development of northern hydrometric networks in the 1980's has severely limited the usefulness of the database as a public service. Many developers have been forced to mount field programs of their own to supplement the meagre hydrometric database. Much of this information is privileged and not readily available even when published. In addition, national standards for the acceptance of third-party data in IWD databanks are rigorous and prevent the ready dissemination of much useful streamflow data. In fact, national standards are not uniformly applied within IWD; the operational criteria

for conventional access stations along the roads in developed Canada and those for the remote-access stations in northern Canada are quite different.

Recommendation:

The public of the northern territories would be well-served if privately-collected, third-party hydrologic information were assembled in an easily accessible database.

It became evident from the survey returns and subsequent discussions at the workshops that the existing northern hydrometric programs lack a response capability to address emerging national and international environmental issues. They also lack the capability to address new or expanded industrial development in the north.

Many respondents felt that only a part of the existing financial resources of the program should be directed to maintenance of long-term hydrometric stations. A substantial fraction should be devoted to a dynamic network to address the site-specific needs of industry and to baseline or project-specific environmental studies.

Recommendation:

Identify long-term or 'master' stations which would be retained indefinitely. Their maintenance should be of higher priority than short-term surrounding stations established for research or development purposes. The short-term, dynamic network should be slaved to the master stations in uniform hydrologic regions.

The Yukon priority ranking of stations to accommodate budget cuts in 1990-91 would provide some helpful information in this regard, but water managers in both territories need to include the clients in the identification of long-term, master stations. Accordingly,

Recommendation:

Strategic network planning of this nature should utilize input from the user community. Ideally, there should be joint planning sessions.

Data users also suggested that new cost-sharing ventures might serve to ameliorate the impacts of decreases in funding for water management agencies. These approaches should be explored in joint network planning sessions. It was noted, however, that DIAND does not have the legal means to receive third-party funds.

Recommendation:

DIAND should seek to establish appropriate regulations and financial structure to receive and manage third-party contributions for jointly-funded northern water management ventures.

A second futures scenario which was to be considered by this study was one where the territorial hydrometric programs would receive increased funding via the Arctic Environmental Strategy.

INAC senior managers were optimistic that such new funding would become available. Funding under AES implies that new programs or re-vitalized older ones must be understood in an environmental context. It is difficult to perceive the granting of new funding without the establishment of explicit linkages.

Should new funding become available, the following elements could form the basis of increased program delivery. These suggestions are based upon the results of this study and related work on single hydrometric station evaluations recently completed in Yukon and still on-going in the NWT. The following recommendations must be clearly defined in an environmental context before being incorporated.

Recommendation:

Improve the data collection programs at existing stations to provide better information at spring breakup in the midst of the annual ice run.

Recommendation:

Improve the mid-winter low-flow measurement program, especially for smaller Yukon rivers identified by DFO as salmon rivers.

Recommendation:

Intensify the data collection program in open water periods for those stations with unstable river beds, i.e., gravel or sand-bed rivers.

Recommendation:

Replace electro-mechanical field instruments with solid-state systems less likely to fail in climatic extremes.

Recommendation:

Dedicate some new resources to initiate short-term, special water management needs stations, i.e., the hydro-electric development needs of Yukon Electric. Period of operation should be identified at the outset. This is a dynamic aspect of networking which could be invaluable in the scientific sense as well as in the management sense.

Recommendation:

Expand into new areas of resource development or hydrologic significance such as the Arctic Islands.

Comparison of the user survey responses to the analysis of the Yellowknife data request log showed that the request log offers broadly similar information to program managers for many survey topics without incurring the expense of periodic user surveys. For elements such as data usage by northern regions and client classification by group, ie., federal government, consultants, etc., the request logs are a useful surrogate source of information. Surveys would still be required to obtain client opinion on matters such as program direction and user needs. Accordingly,

Recommendation:

Data request logs should be maintained on an electronic database in the northern offices of IWD or DIAND WRD.

8.0 Bibliography:

Canada; 1972.; Chapter N-25, an Act respecting inland water resources in the Yukon Territory and the Northwest Territories; Queen's Printer, Ottawa; 20 pp.

Conly, M.; 1991. Pers. comm. re: Four classifications of hydrometric stations in the NWT; IWD,Yellowknife.

Davar, Z.K. and Brimley. Wm. A.; 1989. An audit approach to hydrometric network evaluation: the case of the New Brunswick hydrometric network; in Proceedings of the First National Workshop on Network Evaluation and Planning; Tech. Wkshp. Ser. # 8, IWD, Ottawa; pp.91-104.

Dept. of Indian Affairs and Northern Development ; 1990.; Arctic environmental strategy: a discussion guide.; Queen's Printer, QS-8448-000-BB-A1, Ottawa; 10 pp.

Environment Canada & Indian and Northern Affairs Canada, 1983. Network expansion and resource requirements 1984-89 for Northwest Territories water quantity surveys; IWD, Yellowknife; 27 pp. + map and appendices.

Environment Canada and New Brunswick Department of Municipal Affairs and Environment; 1988. New Brunswick hydrometric network evaluation; Summary Report; Dartmouth.

Goertz, H.;1987: Report on results of the hydrometric data user questionnaire survey for Ontario; IWD, Guelph; 59 pp. + appendices.

Janowicz, J.R.; 1984. Yukon River Basin hydrometeorological data network assessment; in Yukon River Basin Study, Hydrology Report No. 2; Whitehorse

Janowicz, J.R.; 1986. A methodology for estimating design peak flows for Yukon Territory; in symp. proc.; Cold Regions Hydrology, Fairbanks; Am. Wat. Res. Tech. Pub. series no. TPS-86-1; pp. 313-320.

Klohn Leonoff Yukon Ltd.; 1988. Correlation analysis of monthly flow for hydrometric stations, prepared for Northern Affairs Program, DIAND, Whitehorse.

Kreuder, W.L.; 1980. The history of hydrometric stations in the Yukon Territory; WRB, Environment Canada, Vancouver.

Kreuder, W.L. and Leith, R.M.; 1988. Hydrometric network planning and evaluation in the Pacific and Yukon Region; in proc. of the First National Workshop on Network Evaluation and Planning; Tech. Wkshp. series no. 8; Environment Canada, Ottawa; pp.257-267.

McFarland, J.I.; Kreuder, W.L.; Janowicz, J.R. and Leith, R.M.; 1988. Assessment of hydrometric stations operated by Water Survey of Canada in the Yukon Territory; in proc. of the First National Workshop on Network Evaluation and Planning; Tech Wkshp. series no. 8; Environment Canada, Ottawa; pp. 41-80.

McLaurin, I.; Bilozor, W.; and Glennie, A.; 1986. Western and Northern Region hydrometric network evaluation and planning activities; IWD, Winnipeg; 62 pp + appendices.

Pearse, P.H.; Bertrand, F. and MacLaren, J.W.; 1985. Currents of change; final report , Inquiry on Federal Water Policy; Ottawa; 222 pp.

Prowse, T.D.; 1990. Northern hydrology: an overview; Chap. 1 in Northern Hydrology Canadian Perspectives; NHRI Science Report No. 1, Environment Canada, Saskatoon; pp.1 - 36

Wahl, K.L. and Crippen, J.R.; 1984. A pragmatic approach to evaluating a multipurpose stream gaging network; Wat. Res. Invest. Rep. 84-4228; USGS Dept. of the Interior, Lakewood, CO; 13 p..

Water Resources Branch; 1986: Summary Report: Western and Northern Region hydrometric evaluation and planning activities. IWD, Calgary. 76 pp. + fold-out map.

Water Resources Branch; 1989: The adequacy of hydrometric networks in Canada to meet future needs; report to the CCREM Water Advisory Committee; IWD, Ottawa; 35 pp.

Wedel, J.H.; 1986. An evaluation of the NWT hydrometric network; rep.no. IWD-WNR-WRB-HI-86-1; Inland Waters Directorate, Yellowknife; 44pp.

Wedel, J.H.; 1990. Regional hydrology; Chap. 9 in Northern Hydrology Canadian Perspectives; NHRI Science Report No. 1, Environment Canada, Saskatoon; pp. 207-226.

Wedel, J.H.; 1991.; INAC network evaluation: the water resources management perspective; on behalf of WRD, INAC, Yellowknife; Northwind Consultants, Winnipeg; 35 pp. + appendices.

Appendix A:

Yukon, Northwest Territories Hydrometric Data User Questionnaire

Data for streamflow and water levels have been collected in Canada for many years. In Yukon and the NWT this data collection program has been underway for more than 30 years at a few sites, although most hydrometric stations are much younger than that. There are now in 1990, a total of 214 stations in the two territories. This survey seeks your opinion of this program and where it should go in the future.

1. Inland Waters Directorate annually publishes a series of fresh water resource data books. Do you receive them? If you are familiar with them, how could they be improved to better meet your needs?

2. Senior managers within IWD are presently considering the discontinuation of annual paper publication of a number of their data books, most notably, the annual daily streamflow and water level publications. They propose to make the data available on electronic media instead. Do you concur? What electronic media would most suit your needs, eg., in spreadsheet format such as Lotus 123? Annual water resource data are presently available on CD-ROM readers in IWD or Water Resource Branch regional offices. Has your organization availed themselves of this service? Do you have any comments on its usefulness or on how it could be improved?

3. Many northern stations are equipped with data re-transmission facilities via satellite which permits the acquisition of data in near real-time. Have you a requirement for real-time data? From which locations?

4. For existing river stations, data for daily mean flow, monthly mean flow, monthly and annual means, maximum and minimum flows are readily available. Water level stations on lakes and selected larger rivers publish similar data sets for water levels. Available, but unpublished data exist for water levels, ice thickness, water temperatures, and river reach velocities. What types of data have you requested in the past? For which of these data do you have ongoing or future needs?

5. Are the requirements for accuracy and precision met by the water resource data you have used? The historical streamflow data for the NWT are presently undergoing intensive review and, in many cases, extensive revision, especially in previously

published values for high flows and flood magnitude. Clearly, the data in hard-copy publications you already have cannot be changed. Will these revisions have an impact on your planning or your work? How should IWD handle this problem?

6. The hydrometric network in the north is very sparse in comparison to similar networks in the more densely populated regions of southern Canada. The linkage between industrial development and population densities to hydrometric station densities in a network is obvious. Could you describe your region(s) of interest and list the hydrometric stations whose data you have used? Are the water resource data for your area(s) of interest adequate? Should there be other hydrometric stations developed? If so, where?

7. The operation of hydrometric stations is becoming increasingly costly, especially so in times of escalating fuel costs. Northern operating budgets for the Water Survey of Canada, funded jointly by INAC and DOE, have not kept pace. Financial constraints may therefore necessitate an elimination of substantial portions of the existing networks in Yukon and the NWT. Would a decrease in existing networks have an adverse impact on your company or agency? What remedies might be available to address this shortfall of dollars?

8. A number of water licences in both Yukon and the NWT now contain specific terms requiring the licensee to provide water resource information from water bodies, either rivers or lakes, affected by the development. What is your opinion on this matter?

9. The decade of the 80's saw rising concern with the state of the environment. Northeners who long have viewed their environment as one which is relatively pristine, have now become aware of the inroads of pollution on northern environments. These new findings are especially significant to northern fresh water systems. In your opinion, should the hydrometric network in Yukon and the NWT be upgraded to an 'environmental' network and to provide data on other water- or climate related variables? Please comment.

10. The preceding topics and questions may not adequately address your concerns related to northern hydrometric networks. Please feel free to add comment.

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Appendix C: Detailed User Response Summary to the Mailed Survey

Topic 1: Data Book Publications

(a). Do respondents receive data books?

Yes:	38	59%
No:	22	34%
No Response	4	6%

In many responses, the data books were considered to be useful as a general reference tool for a wide variety of applications, from engineering design to their use as teaching aids in universities. In some cases, the data books were consulted on a daily basis.

A common complaint was that the quality of printing and binding of the data books had recently declined. Specifically identified was the character format which was difficult to read, and illegible numbers, especially '6' and '8'. A more legible typeset was suggested.

> " The period of record is often an important variable in network design and the historical summaries could be improved by adding a footnote for this information. Descriptors such as 'manual gauge' and 'ice conditions' that are used in historical streamflow summaries are often useful for network design because they give some indication of existing conditions. Mean maximum and minimum daily, and maximum instantaneous discharges for the period of record would also be useful. Suggest integrating the four main water reports into a single document."

> " Better access to water level information is required. In addition, given the large part of the year when discharge extrapolation from stage is difficult, it would be useful to have daily peak and mean stage records published with the interpreted discharge for critical periods (ie. when B's must be printed). Also, reasonable-fit polynomial equations for the open water rating curves and the years to which they apply should be included in the publications."

Several respondents indicated that many of the data sets were incomplete, especially those from small creeks. It was also suggested that special notes or codes be included in the data sets for those significant events where data quality does not meet standards for publication. These currently appear in the books as days with no published data. In addition, it

was suggested that a more timely printing of the publications would be useful, with a more intensive geographical and temporal coverage of hydrometric areas.

Topic 2 - Electronic Media

Do users agree to an electronic media conversion?

Yes:	39	61%
No:	17	27%
No response	8	12%

The consensus among respondents was that electronic media conversion was a progressive move forward, and would best accommodate those users who have ready access to computer hardware, and who are involved in large-scale data modelling or analysis.

For those with very limited data requirements however, the accessibility of the hard-copy was preferred. Not all data users have the means to make the conversion to electronic media easily, and a wholesale shift from hard to electronic copy data might discourage some potential users.

It was suggested that both the hard-copy, a universally accessible form of data presentation, and soft-copy electronic data, which are becoming increasingly popular, be made available to accommodate all users, at least for the present.

Type of electronic media preferred.

Lotus 123:	26	41%
Data-base:	6	9%
ASCII:	9	14%
No response	23	36%

" Should IWD consider using a commercial software package for data transmission, care should be taken that the program chosen won't deny access to the smaller users. Programs such as D-Base 1V are fine for agencies that can afford a full time data-base manager but are beyond the economic abilities of the small organization."

It was suggested that if Lotus 123 were adopted, version 2.01 be used. This would accommodate version 2.01 users as well as users with versions 2.2 and 3.0 in a choice of 5 1/4" and 3 1/2" discs. User-selected data combinations should be allowed.

Data should also be available in TAB or COMMA delimited ASCII format that could readily be used by software developed for numerical analysis.

Are CD-ROM readers used?

Yes:	22	34%
No:	35	55%
No response	7	11%

The positive responses to this question include 11 clients who indicated that their companies would acquire CD-ROM capability in the near future.

Data storage in this format is useful because it provides direct access to large quantities of information. Future uses of CD ROM may become attractive because of declining hardware costs.

Many users do not have the hardware to make use of the CD ROM service. CD- ROM service is not yet available in Whitehorse.

The current software to read data was described by some respondents as clumsy and in need of improvement Historical monthly summaries should be more directly available for downloading. It was also suggested that a map indexer up-front would be useful. Also suggested were changes to output options to get monthly data in LOTUS or DIF format.

Topic 3: Real-time Data

Do users need real time data?

Yes:	24	38%
No:	30	47%
No response	10	15%

Some users don't use real time data yet, but a number of these expressed future needs.

Reported uses of real-time data were :

- to monitor peak events;
- for flood forecasting;
- for snowmelt/ice jam predictive studies in specific basins;
- for water level information at ferry crossings;
- to schedule oil-industry field programs; and to
- monitor oil-spills in the Mackenzie Delta and offshore.

Specific sites for new real-time stations which were identified in the returns were at:

• all locations which monitor stream-flow and levels in or adjacent to Kluane National Park;

• all stations up-stream of hydro-electric plants. These data would be useful to monitor inflows and evaluate water-release requirements; and

• all stations which are near snow goose colonies.

Northern systems with real-time data requirements are as follows:

- Hay River;
- Peel River;
- Liard River;
- Mackenzie River;
- Mackenzie Delta;
- Tuktoyaktuk Peninsula;
- Kluane Lake drainages;
- Great Slave Lake;
- Aishihik River;
- Giltana Creek;
- Sekulmun;
- Marsh Lake; and
- Slave River.

Topic 4: User Needs

What are the data requirements?

The various kinds of data available from the northern hydrometric database were separated into 10 categories as follows:

1-	Monthly mean flow	6-	Ice thickness
2-	Monthly and annual means	7-	Water temperature
3-	Maximum and minimum flows	8-	River reach velocities
4-	Daily mean flow	9-	Sediment
5-	Water levels	10-	Potability

Most data requests were project specific. Individual requests varied with the nature of the project. Many respondents were not aware of the data available for ice thickness, water temperature, vertical and horizontal water velocity distributions, river cross-section bathymetry, etc. There was also a continuing need for reconnaissance-level information from specific sites not presently in the hydrometric network, and from unpublished, third-party data banks.

> " There is a need for spot measurements of streamflow which may have been obtained by staff members in the past, eg.- M. Alford's spot measurements of ungauged streams. Other data from parties such as Yukon Electric, various mining companies, and Northern Affairs are useful, and an effort should be made to coordinate these into some form of network."

Topic 5: Data Accuracy:

Are users satisfied with accuracy and precision of data?

Yes:	28	44%
No:	6	9%
No response	30	47%

Generally, determination of data integrity by conventional techniques, eg., by comparison with data from other sources, is impossible. There seldom are other data, and thus data accuracy has to be assumed. Many users were aware of potential errors, but were nevertheless, satisfied with data quality. It was suggested that it might be useful for IWD to include data accuracy ratings, ie., estimates of the degree of uncertainty in the data.

There was concern with accurate stage and discharge during break-up. Interpretive statements to describe conditions of flow and ice conditions were suggested. The complicating effects of snow dams at the spring freshet need to be addressed in more explicit ways in data analysis.

Peak flood flow data at a number of locations were thought to be inaccurate. It was suggested that IWD improve this analysis or include a foot-note in the tables to qualify these data.

There were perceived problems with the measurement of low winter flows, partly because most stations are preferentially located to measure summer flows.

Will revisions to historical streamflow data have a negative impact?

Yes:	28	44%
No:	13	20%
No response	23	36%

Changes to historical data, especially to extreme event data, would have a negative impact on many clients. Most preliminary design is based on these data. A comprehensive listing of any revisions and the stations affected should be distributed to all users in both CD-ROM and hard-copy format. A separate guide should be issued regularly to outline both the revisions and the methodologies used to make those revisions. A request form for updated records should be issued with the guide so that users can obtain them easily. Revisions could also be made in the current edition of the Historical Streamflow Summary, and flagged for identification.

> " Revisions will create problems in estimating flows on the Slave River and for modelling flows in the Peace-Athabasca-Slave-Mackenzie system. Suggest simple notification of revisions. Any corrections made now by IWD will only benefit users in the long-run."

Topic 6: Geographic Areas of Interest

Identification of region or station(s), where users presently request data, or have requested historically:

The reader is referred to Table 1, page 19, and Figure 6, page 20, of the main report.

Are data adequate for these areas?

Yes:	11	17%
No:	20	31%
No response	33	52%

More data were needed in all areas, and existing data-bases, while an improvement from the past, are largely inadequate. A specific deficiency was noted for water quality/sediment data.

> " While the coverage of major streams is adequate, little has been done on smaller streams. These are more likely to be impacted by industrial or infra-structural activities than the major systems, and the lack of high quality hydrometric data impedes the ability to respond to applications for development."

> " There is an obvious shortage of data for the high Arctic. Also, suggest updating the Mackenzie Basin system to provide a better understanding of this major northern water source. Other stations should be concentrated in areas where large discrepancies between high open water and low winter water levels occur. More information about low water level periods is needed to facilitate future northern development."

> " Yukon data are inadequate due to the interrelated influences of various mountain ranges and glaciers on weather patterns, precipitation and river flows. The complexity of these interactions make it difficult to develop correlations for new sites from existing data."

> " Territorial data are largely inadequate primarily due to the vastness of the area, making it difficult to coordinate industrial and hydrometric needs. Suggest including agencies such as DIAND Lands and Geology, as well as industry associations such as N.W.T. Chamber of Mines in any hydrometric network planning."

Need for new hydrometric stations:

> " The NWT is downstream of four provinces and the Yukon Territory and therefore is affected by both the quality and quantity of water flowing into it from these areas. In addition, to a large degree, the economy of much of the NWT relies on both renewable resources such as water, and the associated animal life. For this reason, hydrometric stations located near communities would likely provide useful data."

> " More stations should be developed in regions with ongoing or planned developments which affect streamflow or water quality, in a variety of terrain types, climatic regions, drainage areas etc."

> " Great disservice is done by not extending the network to those areas with few or no stations such as in the High Arctic and Baffin Island. Recommend reopening discontinued stations in these regions or installing new gauges to fill regional gaps. Because of emerging

> priorities such as land claims issues, transboundary water negotiations, and cumulative impact assessments of industrial developments, government needs to develop a sound data base on existing water resource conditions that go beyond present network capabilities."

There is also a need for portable stations to be put into 'hot-spots' to support short-term (<5 years) studies.

Topic 7: Impacts of Network Reduction

Would a decrease in existing networks have an adverse impact on your present or ongoing operations?

Yes:	31	48%
No:	13	20%
No response	20	32%

Because the unit cost per station is generally lower in larger networks, a decrease in network size might not necessarily promote real savings. Many respondents felt that it was necessary to have long-term data records in the North in order to measure change from natural variation, human encroachment and climatic change. A main concern was that some stations might be discontinued in sensitive basins that are poorly understood, eg., the Kluane Lake Basin. Streamflow monitoring stations should be representative of neighboring watersheds so that data might be extrapolated. Removal of some existing stations would worsen this situation. Lack of data from the Mackenzie River and its tributaries in northern B.C. and Alberta would have a significant impact on both existing and future developments in the Mackenzie River Basin. Changes to runoff patterns from dams in B.C. or Alberta might change breakup mechanisms, sedimentation and erosion patterns, and water levels along the Mackenzie River.

> " A lack of data results in more conservative engineering designs which will increase the overall project cost. This cost is significant at present, and would increase with a reduction of data sources. For example, without water level data (from Great Slave Lake), the construction costs of the Yellowknife Marina might have been $750,000 to $1,000,000 greater, allowing for construction costs of a one meter higher breakwater crest and a one meter lower dredge depth. In addition, the lack of hydrometric and water quality data is blamed for the Pelly Bay water supply system failure which resulted in salt water intrusions rendering the $750,000 system useless. Future projects such as improvements to the Territorial transportation system, and the

Mackenzie Valley pipeline will need access to as much environmental data as possible."

" A decreased network would impede future large scale programs such as GEWEX and IGBP (International Geosphere-Biosphere Program). As well, any change in the existing network including Rengleng, Caribou, Cabin, Boot, and Trail Valley Creek, with the possible exception of Boot Creek, would have serious implications."

" To discontinue stations on the single criterion of cost is poor management. The strategy of reducing stations with the least adverse impact still leaves the network in a fixed cost position with few resources to meet emerging priorities. For example, there is a growing need for hydrometric and sediment data on some transboundary streams to build an information base that will allow the development of water quantity and quality objectives. To install a new station requires discontinuance of another station. To continue such a piece-meal approach of constantly moving stations to meet today's needs spells disaster in the future. ...suggest rationalizing both networks in terms of location, costs, needs and data quality to produce a modified bare-bones network. As well, future scenarios and potential users must be identified to produce a new vision of the networks and the task is to sell this idea to those who allocate funds. In addition, suggest bringing in new partners to share costs, or devise a system of cost recovery for stations that are installed for specific data users such as mines and utility companies."

Other Comments:

- encourage private agencies to develop gauging sites and submit their data to a central gathering agency;
- increase use of telemetering equipment (DCP) to reduce costs;
- switch to less costly stream gauges and data loggers ie., pressure sensitive, optical;
- subcontract some services to locals to reduce large travel costs;
- use INAC funding from the Arctic Environmental Strategy;
- operate stations for short time periods to collect specific data;
- close stations that wouldn't benefit from further additions of data, eg., Great Bear River which is extremely steady, and Kakisa, where there are 25 years of data. Suggest that beyond some pre-established length of data record, the user should pay for data. As well, some flow data could be correlated with lake levels requiring only the maintenance of a level station as at Lac La Martre;
- correlate data from surrounding stations in the area. If 20 years of data exist and correlation is possible, close station;
- adopt a user-pay approach to all data needs related to compliance monitoring;
- suggest that WSC should seek arrangements with other federal government departments, the territorial government and private interests before reducing their data collection program; and
- suggest putting greater responsibility on resource development proponents and others to undertake site/project-specific monitoring.

Topic 8: Networks and Water Licences (User Pay Scenario)

Should water licensees provide water resource information?

Good Idea:	35	55% (many conditional responses)
Bad Idea:	8	13%
No response	21	32%

Many respondents thought this was a good idea, but almost all were concerned with loss of data integrity from non-standard data gathering procedures. Also, many developers could not afford the equipment and training that would enable them to measure streams accurately.

> " Water licenses usually require data on water quality, sediment load, and to a lesser degree, streamflow. Because hydrometric stations are operated for a number of years (20+) to provide a sound understanding of the water characteristics, this same standard would be an onerous requirement for the water license proponent. Suggest that the Water Board and DIAND discuss hydrometric requirements."

Other Comments:

- the onus of monitoring water resources and ensuring water quality should be on the user; and
- such monitoring should be considered as part of the development costs.

> " ...have had discussions with DIAND regarding the possibility of introducing specific requirements in licenses to better meet both my research needs and the long-term needs of DIAND eg., mine license requirement for controlled basins adjacent to tailing ponds to permit accurate measure of water balance components-eventually leading to more accurate requirements for abandonment."

> " As the water manager, DIAND must readjust its thinking about limited, site specific data requirements for water licences and institute a comprehensive 'hydrological' data collection program in concert with industrial developments."

> " If someone alters flows or levels, they should be responsible for data collection. Not all data need be to IWD standards and accuracy requirements should be specified. As well, if IWD data accuracy standard required, suggest pay IWD in part or full to collect it, eg., Nerco at Duncan Lake."

Topic 9: Environmental Networks

Should there be an integration of environmental concerns such as water quality and climate data gathering into the existing hydrometric network?

Yes:	50	78%
No:	6	9%
No response	8	13%

The concept of environmental networks was clearly one which found favor with the surveyed users. Most of these, however, were emphatic about maintaining the high quality of the existing IWD programs. In other words, expanded data collection programs are great, but not at the expense of the hydrometric program.

An environmental upgrading would require funding from all levels of government in a coordinated arrangement; this would be too expensive for WSC alone. Practically, the siting requirements for a climatological station may be diametrically opposed to those for a hydrological one. Situations such as this could result in large expenditures to collect data that are rarely used. Some respondents felt that the Water Survey should concentrate on basic stream-gauging at the maximum number of sites, rather than curtailing some stations to allow extraneous observations at others.

> " ...not necessary to provide continuous monitoring of water quality which can be handled more intermittently and responsively."

> " The lack of industrial development in the north does not warrant an upgrade."

> " The environment in the North has not been impacted upon any more severely than environments elsewhere in Canada. The mining industry is well regulated and is doing a good job in its part to be friends within the environment in which it works. It is inevitable that there will be impacts, and the focus should be to minimize these."

Several respondents suggested that the primary responsibility of IWD should be to collect hydrometric data. If additional funds were to be made available, then upgrading to an environmental network would be possible. Initially, the concept should be implemented only at critical river sites to minimize costs. A concern was that start-up costs might be prohibitive. It was suggested that simple projects, such as integrating climate stations into the networks would be the best way to proceed.

" It makes sense to incorporate an environmental aspect into the hydrometric network rather than form a new and separate department, possibly duplicating some management and administration."

" There would be significant organizational difficulties to overcome, and the Federal/Provincial Agreements on Water Quality Surveys would be affected, but there is potential for overall operations and cost efficiency."

" ...important need for more sediment data for main rivers, especially for Mackenzie and Liard Rivers."

" Selected stations should be targeted for water contaminant monitoring."

" Information from an upgraded environmental network would aid in the design of new ferry operations, especially data on water temperature, sediment content, and chemical pollution."

" A long term record to provide baseline data for establishing norms and deviations is essential."

" For an area that is largely undeveloped, now is the time to gather benchmark data on the water resources to gauge future changes. Kluane National Park Reserve could be used as a continued undeveloped area for comparisons with water quality in developed areas. As well, there may be some potential in utilizing Park Staff to collect some of the data in and adjacent to the Park area."

" Many of the developers' 'design' data are really calculated values based on a limited number of measurements rather than being measured directly. As well, many data are extrapolated from great distances away. Hydrometric data is only one parameter needed for a complete design and the lack of associated meteorological parameters means that hydrometric data are sometimes not used or are not as useful."

" DOE at large has to consider the integration of its networks. A full eco-system approach would require the participation of many other groups ie., forestry, fisheries, etc., which would be difficult, given the lack of success even within the IWD between its water quality and quantity groups. There are however, a number of international initiatives directed toward such integration eg., Finnish initiative regarding Arctic monitoring; bilaterals with the USSR regarding northern water resources and environmental protection; MAB biospheres; NRB joint research sites. Suggest that IWD move quickly to an international integration of an environmental network considering the circum-polar aspects of a relatively homogeneous hydrologic and climatic regime."

" A long term series of discharge records is of paramount importance in assessing potential climate change indicators. Canada's Arctic hydrometric network is probably one of the best in the world and at a

very minimum should be at least maintained. As well, streamflow measurements in the high north are very sparse, and long term stations there should be increased."

Topic 10: General Comments:

" Data consistency and accuracy over time are the two factors considered when assessing the value of the data and the collection program. If changes must be made, then it would be more valuable having a few high quality stations than many that provide questionable results."

" I sense an IWD bias (in the questionnaire) that comes to a head with the suggestion that the hydrometric network be up-graded to an environmental one. This presumes a superiority over other networks, e.g., those operated by the AES. The problem we face today is getting the biggest bang for our buck, and this requires coordination of all departmental monitoring efforts."

" A more unified approach to environmental management must be implemented that transcends the bureaucratic division of responsibility that currently prevails."

" As the North continues to develop and grow, there will be an ever increasing need for the services and data provided by Inland Waters. Accurate environmental data is critical in the development of safe, cost effective services for northern communities."

" Data collection of a standardized nature is essential for future management. WSC must realize that the products of their programs cannot be qualified easily when the relevance of the work cannot be identified immediately. At some point the data will be crucial for management, especially because our environment is changing so rapidly. We cannot indicate when, but sometime in the next 100 years the need for this type of data will become patently obvious."

" Study basins should be set up in the mining areas in which lake levels are monitored and inflow and outflow measured so that some estimate of natural evaporation can be done. This would help in designing and regulating tailings ponds. Flows should be measured in a representative network of small streams (flows less than 5 or 10 cms) established in the mining areas. This would provide an accurate number of benchmarks for development design by providing trends and annual flow values. The measurements taken by the companies are usually short-term (not all year and not for many years) and it is hard to say how representative the data they collect are for the small drainage basins they are dealing with."

" We would like to see WSC put in other stations for our needs."

" There are a number of agencies collecting raw water quantity and quality data which should be pooled together to substantiate the results and cut down on redundancy and extra costs."

" ...would like to see the addition of an operational person in each main sub-office to perform duties such as (obtaining) lake, reservoir and river temperatures; turbidities; ice properties; and to coordinate researches."

" There is a need for sediment concentration monitoring in the Mackenzie. This would be useful because the data set is still quite limited and the sediment can act as a proxy signal for other drainage basin parameters."

" ...suggest integration of the hydrometric network with the GIS software to produce the best possible data base with which to conduct research, and manage water quality and user demands."

" ...research required to address data collection problems, eg., the effect of slush on water velocities, water loss due to ice and slush formation, complex slope-stage-discharge relationships, reliability of servomanometer systems, indirect determination of high-water discharges, etc."

" It will be very difficult to continue to operate a hydrometric network in the territories that will satisfy all potential users. Because of the size of the territories and the potential for development to occur almost anywhere, it is recommended that INAC, IWD, and the NWT Chamber of Mines and others set up communications to enable network planning at or close to high activity areas or new development sites."

" Hydrometric networks should be expanded to include meteorological and water quality, sediment load data wherever practical. In some cases, developers may be willing to share some of the expenses. If the network is to be decreased because of financial constraints, it will result in less data being collected at each site making it difficult for INAC, IWD and other regulatory agencies to reconcile the integrity of data based on a diminished data base."

" The existence of every station has to be challenged from first principles in order to know clearly what the objectives of the overall data collection program is. Staff time (both in DIAND and DOE) is available only to maintain an inherited network and very little time is available to decide what the direction is and to let simplicity prevail. The current network evolved from many threads but needs to be examined as a whole program."

Appendix D: Detailed Proceedings, Yellowknife Workshop, Mar 05, 1991

Participants included water resource managers from DIAND Yellowknife and Ottawa, IWD Yellowknife; NWT Chamber of Mines, GNWT Transportation, GNWT Parks and Recreation, GNWT Renewable Resources, engineering consultants, NWT Water Board, NHRI, and the Science Institute of the NWT. A list of attendees is located in the last section of this appendix.

1.0 Introduction:

The workshop was introduced by the Chris Cuddy, Chief, Water Resources Division, Ottawa. The purpose of the workshop was to improve understanding of the existing hydrometric network and thereby to facilitate rational hydrometric network growth to address the issues described in the Arctic Environmental Strategy (AES). The federal government has identified a funding level of $100 million dollars for the AES to address four major initiatives, of which water management in the north is one. The AES is focussed on the emerging problems of the north, such as water quality and other water management issues. The user survey and associated workshops were also intended to develop background material to justify the needs for new funding. Rational planning for future networks involves the need to integrate water quality and quantity networks, and a clear understanding of user needs by the planners, hence the survey and workshops. Participant introductions concluded the introduction.

1.1 Northwind Consultants:

Jack Wedel, Northwind Consultants, Winnipeg, prefaced his remarks with several comments by way of introducing a capsule review of user survey results. He suggested that the initial impetus for development of northern hydrometric networks related to mining development such as the sites on the Yellowknife River established in the 1930's to facilitate Giant Mines hydro-electric development. There is great diversity in data needs in today's north, which creates difficulties for rational network design. DIAND's needs are for water management in a developing north. Current priorities for the NWT are instream use, community needs for water supply and sewage disposal, interjurisdictional, recreation, industrial development, highways; and river basin planning.

DOE's requirements from the northern network are for a characterization of the size and distribution of the freshwater resource. There also exists a mutual data need for flood damage reduction programs, the operation of water transportation systems and the management of

interjurisdictional rivers. Analysis of specific uses for individual site data (Wedel, 1991) suggests that many stations in the NWT network are multi-purpose.

Survey responses were originally classified into 14 user categories:

1. Federal government agencies.
2. Territorial government agencies
3. Municipal government
4. Dene/Metis
5. Council for Yukon Indians
6. Inuvialuit
7. Tungavik Federation of Nunavut
8. Petroleum industry
9. Mining
10. Transportation
11. Hydro-electric energy
12. Consultants
13. Academics/Research
14. General Public

General discussion which followed the presentation included the following comments:

- analysis of the NWT data request logs, showing that federal government agencies are the largest users of hydrometric data, was not supported by the survey returns which showed consultants to be the most frequent data user group;
- GNWT Transportation uses streamflow data frequently for engineering design of river crossings or for ferry operations;
- other users, especially native organizations who will need to deal with interjurisdictional water management, will make greater use of hydrometric data in the future;
- the petroleum industry water data needs relate to two main issues - river crossing design for pipelines and spill management;
- the mining industry needs data to manage industrial water use and waste disposal;
- GNWT Transportation (highways) needs data for bridge and culvert design on new roads;

- foreseeable hydro-electric data requirements are for design of small-scale hydro plants to service isolated communities now using diesel generation;
- consultants are major users of data; their products provide analysis and advice for most northern development;
- academics are frequent users of data; and
- the general public who use data in non-scientific ways, eg., canoeists, are not being provided with water information in a useful form.

The topics addressed in the user survey were reviewed. They are detailed in Section 4.0 in the main report and in Appendix C.

Commentary on the development of environmental networks generated lively discussion but no consensus and reflected the diversity of opinion received in the mailed responses. Main concerns centered on the suitability of the hydrometric network as a base for an environmental one, and the potential for the dilution of an existing good product currently generated by the Water Survey of Canada. The comments in the discussion of environmental networks were that:

- there was a concern with common site requirements for different environmental data; ie., site requirements vary with the data being collected;
- the selection of new data collection sites should become a joint exercise involving all agencies charged with environmental data gathering.
- the need to change the traditional mode of operations to meet the expectations of the 90's was urgent, and was stressed by both Mr. Redshaw of DOE and Mr. Cuddy of DIAND;
- the user perception is that hydrometric data consist of streamflow and water levels. In fact, other data, ie., for velocity, ice thickness, water temperature, bathymetry, are available but not normally published; and that
- the NWT, still largely undeveloped, has an opportunity to prevent major pollution from the outset.

1.2 Perspectives on NWT Hydrometric Data Programs

1.2.1 DIAND Water Resources Division, Yellowknife

Brian Latham, Regional Hydrologist, WRD, described the history of the NWT hydrometric network and the effects of the 1975 cost-sharing agreements between DIAND and DOE on network management. In the pre-1975 era, the federal agency, now IWD of DOE, bore all costs associated with the hydrometric network operation. The formal agreement of 1975 created three main classes of stations in terms of funding; 100% federal, those shared 50-50, and 100% territorial stations. Stations were also classified according to means of access and by operational considerations.

An interesting fact is that DIAND Water Resources Division and Inland Waters Directorate of DOE were the same organization in the late 1950's and early sixties before IWD was moved to Energy, Mines and Resources. The name of the common department at that time was Northern Affairs and National Resources.

DIAND reported that operational costs continued to rise throughout the last decade. In 1990-91, two stations have been discontinued and one of two winter field trips for the NWT region have been dropped. This has meant a decrease in the reliability of mid-winter low-flow data, although the impact has been lessened somewhat by the availability of remotely-sensed (DCP) data from many hydrometric stations.

Comments from the workshop floor were that:

- priorities could change dramatically, and should therefore be used with caution in network design;
- stations should contribute to priority elements to justify funding from DIAND;
- changing priorities contribute to network dynamics; funding should be set aside to accomplish necessary changes to the network; and that
- instream uses, while ubiquitous, might nevertheless have a bearing on the precise siting of new stations.

It was difficult for DIAND to predict future trends in network development with any certainty, given the expected influx of resources from the AES, but it was fairly certain that funding for the network from their A-base resources would be reduced. New funding sources from other branches and agencies might accrue to environmental stations designed to collect data other than just streamflow and water level

1.2.2 Research and Academia:

The research and academic agencies' perspective on hydrometric networks was given by Dr. Terry Prowse, NHRI, Saskatoon. Dr. Prowse pointed out that:

- streamflow data in periods of ice effect were generally poor, especially at breakup. Improvements might result from cooperation between research agencies and WSC to improve flow measurement capabilities;
- the Arctic Islands database was practically non-existent;
- the hydrometric network managers needed to link their programs to the issues of climate change, to long-range transport of pollutants in the atmosphere and in large rivers, and to tap into international programs, eg., CRISIS, GEWEX, designed to address these issues;
- more attention needed to be paid to snow elements in the hydrologic cycle, especially to the physical processes during snowmelt;
- remote climate sensors should be established at physically-suitable, regional hydrology stations in the network;
- linkages needed to be developed between snowmelt models and groundwater regimes in regions of permafrost. The suggestion was made that seasonal active layer development be tracked at existing snow courses to initiate such linkages;
- river ice processes at the breakup are still poorly understood. Spring breakup floods cause 40% of the flood damages in Canada. Floods are important to the biologic regimes of deltas. Streamflow data from WSC is fundamentally useless in ice-jam flood periods; water levels are the critical data. Such conventional data need to be augmented with other data acquisition techniques, eg., photo records. The water survey in Hungary has done some excellent work in this field. The Canadian *River Ice Booklet* provides instructions on necessary documentation for freezeup and breakup ice events;
- sediment transport rates during the breakup are virtually unknown because of sampling difficulties. At breakup sediment transport is a very dynamic phenomenon because of high velocities under and around jams, associated scour and the flushing action of released jams. High sampling rates are required to track the changes;

- the spring breakup is considered to be the major aquatic, biological event of the year since it controls riverbank characteristics and its vegetation, and therefore the biological communities living there;
- winter flows need to be defined with improved accuracy. Late-winter low flows are often not as small as the low flows during the freezeup;
- northern water resources, and consequently network planners, are under increasing pressure from development for municipal water supply, hydro-power, diversions, and in the mining and hydrocarbon industries;
- global climate change is an issue which needs to be considered in northern network design. Climate change will generate a decrease in arctic ice cover, will change wetland and permafrost regime, and create a rise in mean sea level;
- arctic contaminants brought into the north via the atmosphere or by north-flowing rivers need to be monitored in snowfall and in the water;
- the Mackenzie Basin continues to be the major focus for research, but at the very least, other basins in northern Canada need to be characterized for hydrologic response, water quality and their linkages to physical basin characteristics; and that
- station location may be important, but the questions of what needs to be done, and when, are equally important.

1.2.3 Engineering Consultants:

The presentation by Vic Menkal, project engineer with Ferguson, Simek and Clark, on behalf of engineering consultants stressed the economic benefits of hydrometric data in the right place, and failing that, the worth of regional data. Examples of design failures of bridges, breakwaters and water intakes because of inadequate water data were cited. A $200,000 saving in the construction of the Yellowknife Bay breakwater was realized from efficient design of channel depths and breakwater height. Efficient design was possible because of the long-term water level record available for Great Slave Lake at Yellowknife. Structures are built regardless of the availability of hydrometric data, but in their absence, designs are conservative and the costs are much greater.

Other comments made from the floor were that:

- consideration should be given to close ties between GNWT Five-Year Capital Plan and hydrometric network planning;
- water data requirements vary with projects;

- good regional, water resource models would be helpful to project designers;
- the existence of all the water databases aren't well known. A hydrologic bulletin board in a public forum might assist in advertising databases;
- there is an insufficient groundwater database for proper design of waste disposal facilities;
- many consultants don't know about some of the data that are available and consequently over-design facilities; and that
- the high cost of groundwater research hinders data acquisition. Also, there is a prevailing mind-set in the north that groundwater is not important.

1.2.4 IWD Yellowknife:

DOE made their presentation in two parts. The first by Arthur Redshaw, Chief, NWT Programs, Yellowknife, stressed an all-out IWD drive to advertise water resource products. A first step in this drive was to create a new awareness in staff of the need to serve the general public of the north. The agency has a commitment to continue the river basin overview report series in the NWT; work is underway on the Nahanni River Basin Overview. Other initiatives for 1991-92 include interpretive reports, fact sheets, newspaper articles, and public-area bulletin boards. In terms of environmental networks, IWD has reached an agreement for the deployment of AES climate sensors at selected hydrometric stations. Two are now in place; four additional stations are to be installed in 1991. NWT water data will be available to consultants, the public and other agencies from IWD offices in Yellowknife, Inuvik, Fort Simpson and Fort Smith.

The second part of the DOE presentation by Malcolm Conly, Regional Hydrologist, was an evaluation project for all federal hydrometric stations in the NWT. It was designed to complement the recently-completed DIAND station review. Some initial results are a new network database in Lotus 123, detailed, integrated station profiles and the development of a revised set of federal priorities for their interest in northern hydrometric networks. The study could not address the regional importance of federal stations because only half the NWT network is being studied. This limitation also will affect its ability to address the question of integration with other networks, eg., climate, water quality, snow course. Clearly, a future need is to generate an holistic evaluation of the entire network by integrating the DIAND report with this one. Mr. Conly's concept of network overlaps developed in this study is described in Section 2.4 of the main report.

1.2.5 The Mining Industry:

The mining industry, represented by Gary Halverson, Chairman of the NWT Chamber of Mines, suggested that the concerns with high network costs, while real, needed to be put in the perspective of environmental data collection programs now required from the industry. For example, the environmental data collection and monitoring costs for one mining company, Giant Yellowknife, were greater than the cost of the total hydrometric program in the NWT.

Other significant comments were that:

- industrial development in the NWT began with the mining industry in the 1930's;
- the NWT mining industry presently employs approximately 2000 people with $2 billion in annual sales at seven mines, two on tidewater, two fly-in/winter road, and three on the Yellowknife highway network;
- future expansion will be accelerated as southern resources are used up;
- the poor mining representation at this workshop reflects a lack of understanding of the value and usefulness of hydrometric data to the mining industry;
- increased funding for the hydrometric network means more taxes for those who can ill afford it;
- the mining industry is heavily regulated, eg., by the Water Board since the 1970's, from exploration phase through production and eventual closure;
- 140 hydrometric stations means one station for every 300 people in the NWT, but also means one station for every 25,000 square km, and the station distribution is not uniform;
- specific site data are needed for individual projects. Stations could be moved if project doesn't develop;
- companies now collect significant quantities of environmental data in all phases of their activity;
- all mines have a commitment to minimize environmental damage, even though environmental data collection programs are very costly; and that
- Nerco, DIAND and DOE now cost-share three stations. Further co-operative ventures were invited. There was a concern that such ventures might be in competition with the private sector, ie., consultants. Consultants, however, rarely engage in long-term data gathering. Better communication between the NWT Chamber of Mines and DIAND/DOE could resolve such concerns at the outset.

There were also some concerns that southern consultants were insufficiently expert with the details of northern hydrology.

1.2.6 Transportation:

The transportation industry spokesman, Pietro de Bastiani, Manager, Marine Facilities of GNWT Transportation, described hydrometric data needs as it related to ferry crossings on major NWT highways, to the design of river crossings for new highways in the NWT, and to marine facilities. Some of the highlights of the GNWT Transportation presentation were that:

- GNWT Transportation has assumed responsibility for roads from DIAND;
- increasing sea levels are a major concern to long-term planning of marine facilities;
- there are four existing ferry crossings on NWT highways at Fort Providence, Fort Simpson, Fort McPherson,and Arctic Red River. Camsell Bend crossing will go into operation in 1993; river stage forecasts will be required for safe operation;
- Peel River forecasts for the Fort McPherson ferry operation would contribute to the efficiency and cost effectivesness of ferry operations. Especially useful would be advance warning for mid-summer, rainstorm floods;
- ferry operations at Fort Providence will continue for the foreseeable future. The ferry could be put into operation before the spring ice-run to provide service in the gap between the ice-road closure and the beginning of the ice-run, but breakup forecasts would be needed to do this effectively;
- ice-thickening on the ice-road by spraying is an effective means to speed up road building. GNWT Transportation could contribute information to an ice-growth databank;
- contaminant spills at ferry crossings are a concern. The agency would participate in a study relating risk from various dangerous goods and river flow;
- the high cost of Keewatin District re-supply from Churchill has triggered a feasibility study to examine a central, marine supply depot in Keewatin linked to other communities with winter roads;
- inter-community roads take priority over the major east-west highway in the GNWT long-term transportation plan. Of all major highway proposals

in the plan, the Yellowknife-Bathurst Inlet link has highest priority because of the mining potential in the region;

- a Mackenzie Valley highway, although not needed for pipeline construction and operation, might nevertheless, be considered for a joint industry-government venture;
- GNWT spends $37 million annually to maintain and improve current facilities and are open to joint ventures to make their operations more cost-effective; and that
- total re-alignment of the Yellowknife-Fort Providence highway is under consideration, partly in response to on-going problems with stream crossings.

1.3 Future Directions:

The concept of master-slave stations in a hydrometric network was presented by Northwind Consultants. Comments from the ensuing discussion were that:

- approximately 30-50 stations should be identified from the existing network for long-term operation, and be designated as master stations;
- this 'master-station' network would form the basis for hydrologic extrapolation to determine where short-term satellite stations would be needed;
- correlation statistics would rarely be sufficiently rigorous to derive daily flow data for a region;
- master stations would be the candidates for multi-disciplinary, integrated network planning;
- in the event of network reductions, master stations would be the last to be cut;
- a regional water resource inventory would be considered to be complete when pre-determined statistical levels of correlation between stations were attained; and that
- the dynamic nature of the satellite station network would provide managers with the flexibility and resources needed to address project-specific information requirements.

The creation of environmental water resource networks requires definition of specific water resource regions based on hydrology, climate, geology, vegetation and land-use information. An 'interested agency' co-ordinating group needs to be established to exchange information and to unify network planning.

Data or information needs by industry were identified by workshop participants and are shown in Table 2, Section 5, page 34 of the main report. A number of qualifying comments related to specific needs stated that:

- many of the data needs for highways are design phase, and therefore short-term requirements;
- water quality data for mining are required in the exploration/development phase from an intensive program to delineate baseline conditions. In the production and shut-down phases, a modest long-term monitoring program is generally the norm;
- most of the data needs identified for marine transportation are site-specific;
- the instream uses identified are for the maintenance of 'traditional' life-styles. It was suggested that data assembled for this purpose be compared to traditional knowledge; and that
- for communities, the data needs for velocity, design flows, and sediment regimes are for design and operation of community water supply and sewage disposal facilities.

1.4 Workshop Conclusions:

User community needs for water resources information identified in the course of the mailed survey and these workshops will be provided to the NWT and Yukon Hydrometric Coordinating Committees and their administrators. It was also noted that:

- this information and hydrometric data in general must be more accessible and be made known more widely;
- a beginning must be made to collect data to deal with climate change and arctic contamination, eg., snow water quality. These must be identified as new activities to departmental planners;
- a decision must be made about what the northern water resource network will look like over the next 20 years;
- the issues posed by new problems must be identified as must the contribution of the hydrometric program toward their resolution;
- DIAND and IWD must improve communications with their users and must adapt their water data programs to meet user needs; and that
- an improved information program for Nahanni National Park has now been implemented.

1.5 Workshop Attendees:

P. de Bastiani	Transportation, GNWT	Yellowknife,	(403) 920 6179
M. Conly	IWD, DOE	Yellowknife,	(403) 920 8492
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T. Prowse	NHRI, DOE	Saskatoon,	(306) 975 5737
A. Redshaw	IWD, DOE	Yellowknife,	(403) 920 8500
K. Robertson	Ren.Res., GNWT	Yellowknife,	(403) 920 6203
R. Seale	Tourism & Parks, GNWT	Yellowknife,	(403) 920 6167
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Appendix E: Detailed Proceedings, Whitehorse Workshop, March 7, 1991

Participants included water resource managers from DIAND Whitehorse and Ottawa, IWD Whitehorse and Vancouver; DFO Whitehorse, EPS Whitehorse, Yukon Transportation, Yukon Renewable Resources, City of Whitehorse, Yukon Electric Company, and NHRI. It was noted with some disappointment that native groups, the mining industry and consultants were not represented at the workshop. A list of attendees is located in the last section of this appendix.

2.1 Introduction:

Dave Milburn, Senior Analyst, Water Planning and Management Section of headquarters office of the Water Resources Division, DIAND, Ottawa provided a brief overview of the purpose and expected results from the workshop. He introduced Jack Wedel, Northwind Consultants, Winnipeg. Mr Wedel provided a brief resume of some of the preliminary results of the mailed survey and outlined the 14 user categories and 10 data types used in classifying the returns. It was noted that government agencies were the most frequent users of hydrometric data.

2.2 DIAND Whitehorse Presentation

Ric Janowicz, Acting Regional Manager, Water Resources Division, Whitehorse, provided historical background for the hydrometric program in Yukon.

The first hydrometric stations began operations in response to site-specific information requests for navigation, hydro-electric and mining requirements. Gradually, the early network operation changed from being project-oriented to a network for baseline data acquisition.

As elsewhere in Canada, 1975 marked the year of formal agreement between DOE and DIAND to operate hydrometric stations in Yukon. The initial co-ordinated network consisted of 37 stations, 19 classified Federal, 7 Federal-Territorial, and 11 Territorial. The network grew to 52 stations in the five years following.

A second five-year plan was approved in 1978 to cover the years, 1979-84. Northern Canada Power Commission, now Yukon Electric Company Ltd., became party to the agreement for network management. The network was expanded to 73 stations in this period. DIAND costs in 1979 were $60K capital, $156K operation and maintenance while Yukon Electric's contribution was $20K for operations and maintenance.

A third 5-year plan was not approved by Treasury Board for the period following 1983. Curtailment of even inflationary increases in recent years has affected network management and product delivery. Escalating costs, the DIAND contribution in 1990 was $297K, have stressed the network and its continued support at existing operational levels is not possible.

In anticipation of network reduction, individual station profiles were produced to set priorities. In 1990-91, a $30K shortfall in DIAND funding was projected. The preferred option to meet this deficit was to discontinue northern Yukon stations, approximately 25-35% of the existing network. A reprieve was provided by a management decision to cover the shortfall. Presently, operating and maintenance costs continue to rise with no corresponding rise in A-base dollars for the program.

A suggestion that operational economies might be derived from joint operations of water quantity and quality networks was not considered to be effective for the present Yukon networks. Only five water quality stations are operated informally by DIAND/DOE on Eagle, Liard, Yukon and Teslin rivers. EPS operates short-term, site specific water quality sampling programs as the need arises. The City of Whitehorse samples water quality at 14 sites.

2.3 Yukon Water Quality Programs:

Gerry Whitley, Administrator, Pollution Control, WRD Whitehorse, described the philosophy of the pending Yukon Water Quality Agreement. It's focus is on development of a long-term baseline water quality network to sample 'normal' or traditional parameters. However, the emerging needs are for data on organo-chlorines and biological contaminants. The high cost of such programs could be accomodated if the regional water quality network adopted a 'recurrent' sampling approach which would sample regional characteristics as periodic 'snapshots'. This approach in Yukon water quality characterization could be done for 1/3 of the proposed budget dollars.

Two problems with the proposed Water Quality Agreement were outlined by Mr. Whitley. The first is that most of the long-term baseline stations proposed would be for glacial systems in southern Yukon, but most of the Yukon Territory north of the Ogilvie Mountains is thought to have been unglaciated. There exists no present knowledge about what drives these water quality regimes nor is there likely to be any significant information increase because of the very high operating costs in that region. Secondly, it has been difficult to convince the central agencies in federal government of the viability of the 'recurrent' network operational scheme.

2.4 Inland Waters Directorate, Vancouver, Network Overview:

Wally Kreuder, Head, Hydrology Division, Water Resources Branch, IWD Vancouver, provided historical background, network statistics and hydrologic perceptions for the Yukon hydrometric network from the federal perspective.

The earliest stations in Yukon were at Whitehorse and Teslin on the Yukon River. For the whole territory, 1700-1800 station years of hydrometric data, available as daily flows and statistical summaries, have been accumulated. Of the present 74 stations, 63 are streamflow stations. Of these, 38 now have 15 years of record and 22 have record length greater than 15 years. Streamflow station density is approximately one station for every 8000 km^2. One-half the streamflow stations measure catchments < 6000 km^2. Most of the Yukon landmass, 88%, is presently gauged and this provides reasonably good information about total freshwater discharge to the sea or, alternatively, average annual runoff per square km.

The comments following the presentation were that:

- Yukon compares fairly well with World Meteorological Organization stream-gauging standards of one station per 4000 km^2. There are presently five stations on catchments < 500 km^2; and that
- the mailed survey returns suggested a need for stations on small catchments. DIAND has operated a number of such stations in the short term historically, and some of them were subsequently turned over to WSC for long-term operation. Most of the initial needs were for site-specific requirements, eg., project design, and were given over to WSC for long-term operation when those needs were fulfilled.

2.5 Fisheries and Oceans:

Al von Finster, Technical Officer, Habitat, DFO Whitehorse, indentified a need for improved information for mid-winter low flows in creeks which served as over-wintering systems for salmon. The problem with WSC data was created by the standardized listing of zero-flow on creeks, when, in fact, good baseflow was maintained through coarse bed materials. Potential developers were being granted licences to alter streamflow on the premise that the WSC data cited a zero-flow condition which precluded salmon usage of the system. Consultants hired by developers tend to use WSC data and their sampling sites. The result is that there is an on-going disagreement between fisheries biologists on the one hand, and WSC and engineering consultants on the other.

Mr. Von Finster suggested that the engineering bias of the WSC program tended to diminish the biological necessities of accurate low-flow monitoring in winter, a regime vital to fish populations.

A final concern was with the impacts of industrial effluent discharges in the winter and their severe biological impacts.

The ensuing discussion on this fine distinction between sub-surface groundwater movement and actual surface flow emphasized the importance of these small mid-winter flows in salmonid streams. One solution, suggested by WSC, was to establish a new flow category, 'Water flow present but unmeasurable'. The protection of riverine biology was considered to be of top priority by the water resource managers present. Downstream dilution models, such as RIVMIX, could be used on a monthly basis to assess impacts of pollutants. It seems likely however, that such 'off-the-shelf' models would need to be modified to fit specific river hydraulics before successful utilization could be realized.

2.6 Survey Results Discussions:

2.6.1 Regionalization:

Mr. Wedel suggested that a division of Yukon into three regions by drainages could be used to classify the survey returns. The suggestions for Pacific, Arctic and Yukon River basins was considered to be inadequate and the Porcupine and Alsek basins were suggested as additions.

Mr. Janowicz stated that a more realistic division into four regions had in fact been made based on hydrologic elements. The four regions were:

1. interior;
2. western mountain - glacial regimes;
3. northern interior, the Ogilvie, Richardson montane regimes; and
4. arctic - the Yukon north slope.

The regions so identified were distinct by annual hydrograph shape, and had been derived from statistical analysis, eg., correlation, cluster and discriminant analysis. The delineation was also supported by differences in regional characterisitcs of permafrost . These regions were subsequently used in the analysis of survey returns.

2.6.2 Unpublished data for Yukon:

Water Survey of Canada can supply unconventional data on a variety of media if requested, but often users do not know of its availability. Data types, available but not normally published, include:

- water levels at large river streamflow stations, of interest to navigation companies;
- ice thickness from discharge measurement survey notes;
- water temperatures from WSC survey notes, City of Whitehorse inlet water temperatures for the 1970's;
- short periods of unpublished, continuous streamflow data, available from IWD in Vancouver for a number of sites important to the water quality program;
- sediment data for Yukon , generally sparse and of short duration. Six stations have been operated for varying lengths of time in Yukon to serve fisheries or mining information needs. A sediment transport model is in development to assess effects of placer mining on rivers. Its development is being delayed by the lack of calibration data; and
- City of Whitehorse potability data, for periods from 1 - 5 years depending upon the parameters sought.

The lack of other data for potability of surface waters in Yukon was attributed to the almost universal use of groundwater for domestic use. There is not an active program in Yukon presently to assess surface water potability.

Water Survey of Canada is re-structuring to combine water quantity and quality programs into a new, environmental surveys group.

2.6.3 Real-time data

Real-time data are needed for management of water licences. Provision of such data to clients for other purposes is not a normal operating procedure because the raw data need to be verified by WSC first, especially from sites with unstable instruments or river channels. If dissemination of real-time data were to be approved, their preliminary nature would have to be emphasized. Such data can only be used as indicators of trends, not as absolute values.

2.7 Academic and Research Presentation:

Dr. Terry Prowse, Project Leader, Northern Environment, NHRI, Saskatoon, presented perceptions of the northern hydrometric network from the perspective of the research and academic community in Canada. In summary, the talking points in his discussion were:

- the deficiency in data on snow, especially in the NWT;
- snow-water-equivalents, which can be measured with remote-sensing techniques;
- Cryospheric Systems (CRYSYS), a NASA program which supplies data to Canada for snow, glaciers, and floating ice. The hydrologic data acquistion agencies in Canada would likely benefit from coordination of their programs with this initiative;
- other data needs in northern Canada for:

- meteorological variables - add inexpensive sensors to hydrometric instrument packages;

- radiation data - present status is pitiful;

- permafrost - active layer role in hydrologic cycle. The suggestion was made not to stop data gathering at snow courses with the annual melt, but to increase the scope of the survey into the spring and summer to track the changes in active layer development and its moisture content; and

- river ice - provide water level data during breakup in addition to WSC flow estimates. Increase recorder clock speeds to provide better stage discrimination during spring ice runs and jams.;

- WHAT should be measured in spring breakup needs definition. Suggested were:

  - floods in spring, related to water levels, not flow, and the former can be obtained photographically. Presently, we know almost nothing about water levels at spring breakup;

  - sediment sampling. There is no record of sediment flux for spring breakup, a period of high water levels and extreme velocities;

  - measures of water quality. These need to be obtained because they measure the suspected major, annual inputs into the river system.

  - morphological impacts of the annual ice run on riverbanks and floodplains, which need to be documented because these phenomena may be the biological reference point for these features for the rest of the year; and

- better documentation for the low flow regimes at freezeup, especially on larger rivers like the Yukon, Liard and Mackenzie rivers. Very low flows at freezeup seem to be common, but virtually no data exist to document their occurrence or prevalence in the north.

2.7.1 Development pressures

Northern water resources experience stress from municipal, oil and gas, and mining developments. To address these properly, new information is needed on other elements of the hydrologic cycle aside from surface water flow; information on elements such as evaporation for example, to improve the understanding of water balances in a system. Contained basins, such as mining effluent holding ponds or community sewage lagoons, might be suitable to measure evaporation accurately. Understanding of previously undefined water balance components would enable improved water management practices.

2.7.2 Evolving issues: climate change and global contamination

The impacts from these global issues need to be addressed in the context of northern water resources. Some expected changes and their impact on northern hydrology were:

- global warming, that will decrease the length of the northern winter because atmospheric moisture levels will rise and consequently, increase orographic precipitation in northern mountains. Response of Yukon glaciers to more snow is unknown as is the surface water hydrologic response. Should Yukon glacier surveys be re-activated? The impact of a warmer climate on regions of discontinuous permafrost and therefore on the groundwater regime could be significant, especially in the Yukon which makes large use of groundwater for potable water supply. Another expected impact from the melting of permafrost could be the loss of large wetland areas, now present because of an underlying, impermeable frozen layer;
- long-range transport of pollutants. The residence time of pollutants in cold air masses is much longer than in temperate regions. The sources for arctic haze are industrial North America and the USSR. Northern levels of contamination can be measured by water quality analysis of snow precipitation.

Global Water and Energy Exchange Program, (GEWEX), another international initiative, represents an opportunity for integration of Canadian surface water data programs with international environmental concerns. The Canadian focus will likely be the Mackenzie Basin in the NWT, but the Peel and Liard basins are subsidiaries of the larger Mackenzie Basin, so there are implications for Yukon data programs.

2.8 Yukon Electric Company Ltd. Presentation:

John Murray, Supervising Engineer, Yukon Electric Company Ltd., outlined some of the ongoing data requirements for Yukon Electric, engaged in site evaluations for the establishment of small-scale hydro plants on a number of rivers in Yukon Territory. For the most part, their areas of interest were located on ungauged catchments. Yukon Electric has therefore been operating a reconnaissance-level network of 15 stations with contract help from Monty Alford, ex-employee of IWD Whitehorse, and assistance from WRD Yukon. One of the reasons for the large number of sites required was the difficulty of deriving correlation data from long-term hydrometric stations in the mountainous terrain of interior Yukon. Some of the feasibility studies are in the Surprise Lake basin near Atlin, and in Drury Lake, Marn Lake and Marin River catchments.

New strategies and data programs are needed to determine water losses from wetlands and through groundwater systems. There are also data needs associated with impact studies on

behalf of fisheries, land use, and with studies to measure the total energy potential of a river system.

The chief interest in conventional data is for low-flow periods. Maximum flows are important too, but the low flow regime is critical to power plant operation and to the fisheries resource.

One suggestion for the Yukon was the establishment of a 'non-conventional' data bank to accumulate all these tidbits of design-level data. It was noted that much of the data now required by Yukon Electric had already been gathered by other studies, eg., by the mining industry.

Yukon Electric asked for advice on instrumentation systems compatible to WSC standards for use in their independent investigations. WSC responded that their operational stations were now in the process of being re-equipped with solid-state instruments. Firm costs were not yet available. The new instruments could approximate the continuous sampling mode of the old, analog recorders with small-interval (15 min.) samples, but had the advantage of varying the sampling rate according to the rate of change of the parameter being measured. In addition, sampling for other environmental data became simply a matter of connecting an appropriately-deployed solid-state sensor.

2.9 Subsequent Comments:

Network inclusion of special-project, short-term stations was criticized on the basis of economics. It was stated that the Northern Affairs Program, WRD, has the capability to operate short-term site-specific, project-oriented studies at a fraction of the costs associated with a WSC program. There was pessimism about the ultimate success of a collaborative program between WRD and WSC in this regard.

In the case of B.C. Hydro, there was a need for 16 new stations to assess the viability of an Alcan hydro project.

It was not considered to be possible to design a network to suit everyone's needs. The concept of a baseline network to operate in the long-term, complemented with short-term project-specific network stations, was one plausible solution suggested.

If private industry established their own project stations, the data might be inaccessible because of its proprietory nature. There might also be problems with the quality of independently-collected data.

In the event of network expansion, new stations should be located so as to represent carefully selected physiographic and/or hydrologic regions.

Development of better forecast models might result from better deployment of instrumentation packages. This in turn, might make funds available to operate a flexible, project-specific network in concert with the long-term core.

The costs of hydrometric data acquisition now consume one-half the annual budget of the WRD Yukon. There was a concern with proposals that cost more money with no increase in network size. Consideration should be given to generation of lower quality data for substantial savings in dollars. The Northern Affairs Program costs for the hydrometric network are greater than those for all water quality work being done in the Yukon. It was recommended that the Yukon hydrometric network be collapsed to the core stations only, and that the monies thus freed be used to implement some new program elements such as those suggested by Dr. Prowse.

The levels of current funding of the Yukon hydrometric network and Northern Affairs Program's other needs were constraints on current Yukon network operations. Other alternatives to funding such as Atmospheric Environment Service support for climate stations, needed to be sought.

There was strong disagreement with the earlier suggestion to reduce data quality in order to effect economies in network operations.

2.9. Information Needs by User Groups:

The final session of the day identified data requirements from the perspective of individual user groups. This involved a level of role-playing, since many of the user groups were not present. The suggestions received from the workshop are summarized in Table 3, Section 5, page 41 of the main report.

2.10. List of Attendees:

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G. Ford	DIAND WRD	Whitehorse	(403) 667 3104
E. Gibson	Yukon, Transportation Eng.	Whitehorse	(403) 667 3005
R. Gregory	DOE WSC	Whitehorse	(403) 668 2161
S. Hamilton	DOE WSC	Whitehorse	(403) 668 2161
R. Janowicz	DIAND WRD	Whitehorse	(403) 667 3145

W. Kreuder	DOE WRB	Vancouver	(604) 666 3606
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